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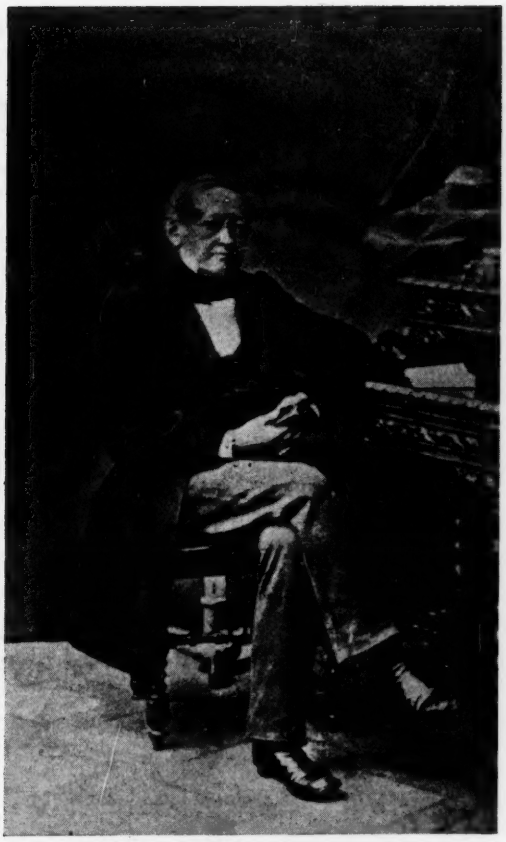

JOHANN CHRISTIAN POGGENDORFF
(1796–1877)

In 1824 this German physicist, born in Hamburg on December 29, 1796, founded the *Annalen der Physik und Chemie*, which became the foremost scientific journal in Europe. He was its editor for 50 years. His "Biographisch-literarisches Handwörterbuch zur Geschichte der exacten Wissenschaften" (two volumes, 1863) contains notices of the lives and labors of mathematicians, astronomers, physicists, and chemists. This publication was continued by other hands after his death. His literary and scientific reputation brought him many academic honors. He declined to accept any professorship, devoting his energies to the editorship of the *Annalen*, and to the pursuit of his scientific researches. He died at Berlin on January 24, 1877.

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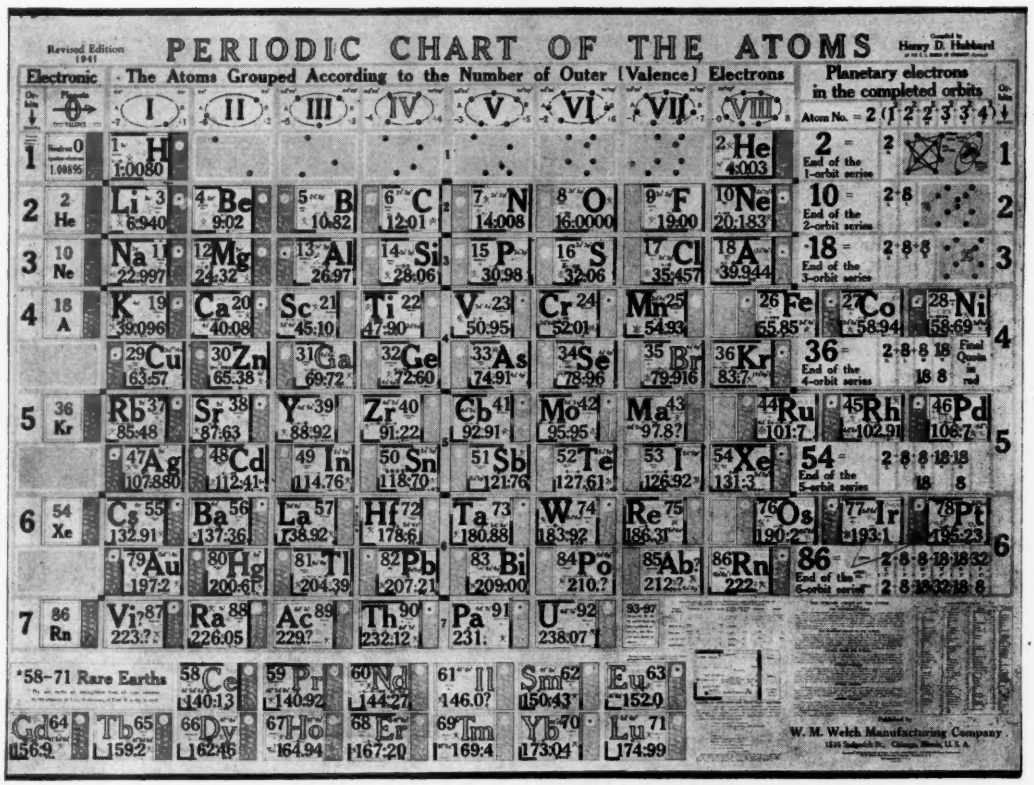
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Editor's Outlook

IT MAY not be altogether a coincidence that the influx of enormous enrollments into our colleges this spring and next fall will be accompanied by widespread changes in curricula and fundamental educational policies. The switch from wartime to peacetime schedules is obviously the cue for making other changes which may have been under consideration for a long time.

So we find, all over the country, many colleges going back to their normal routines, giving up "accelerated courses," and generally cleaning house. (The latter phrase is more literal than figurative, in view of the shortage of housing for the large number of returning and incoming students.)

Technical schools are tightening up their standards again and trying to catch up with technological progress, while at the same time giving heed to the demand for "broadening influences" to bring about appreciation of social problems and implications which war has accentuated.

Other institutions are strongly arguing the case for the "liberal education" which the war has had so little time for, and which is now advocated as the cure for the epidemic of ills which we are presently to experience. One senses in this arguing a bit of uncertainty: a fear that much ground has been lost to the barbarians which can never be retrieved; but on the whole a hope that the world has become so tired of technology that it will rush to the "liberal studies"—whatever they may be, exactly. At any rate, liberal education is aggressively on the defensive.

Apparently in keeping with the trend in politics and economics, the new liberal curriculum is to be a "planned economy" of education. Freedom of electives has apparently run amuck in the past, leading to the "cafeteria" plan of courses, according to which a student gathers a plate of this and that and a cup of something else onto his educational tray and ends up with a bad case of intellectual indigestion as a result of the unbalanced diet and the incompatibility of mental foods. Such is the diagnosis, at any rate.

All this is to be changed. Now we shall buy a strictly table-d'hôte dinner, carefully planned as regards the proper nutritional elements and the health-giving vitamins. Some slight attention will be paid to individual food allergies and one's choice of desserts, but by and large you will take what the house offers you, because it is good for you. The style of cooking will vary from place to place, but the meal tickets will have pretty much the same shape.

The sciences will be the meat of the menu, and the ration allowed will be generous. In fact, chemistry will probably come in for rather a boom. But very likely it will be a question of a little chemistry going a long way. In some places it will be survey courses in physical sciences; in some it will be a fitting together of semester courses in several sciences; in others it will be merely more of the same thing we have had before.

But it brings a general problem clearly before us. We will be expected to teach chemistry to more people than ever before, and generally for a different purpose. What are we going to teach them? It is not quite sufficient to answer: "Why, just teach them *chemistry*." For the content of the field of chemistry has increased so enormously that the problem of choosing that portion which is most necessary and "fundamental" will be very difficult.

(Continued on page 122)

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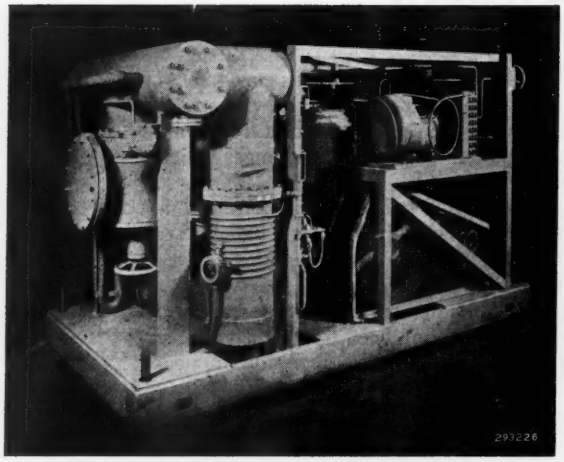
What's Been Going On



ROTARY PUMPS AND DIFFUSION PUMPS ARE USED IN SERIES

Molybdenum

Limitations on the production of molybdenum in "chunks" of large size and multiplicity of shapes have been removed by Westinghouse engineers. Furthermore, the cost per pound has been reduced to roughly one third.

The very qualities of "moly" that have seemed so long attractive to designers have been the very ones to block its production in large sizes and complex shapes. Moly melts at 4748°F. (iron, 2800°; copper, 1976°). Thus, although pure moly in powder form can readily be prepared from its natural oxide, it cannot be melted like other metals to form large solid pieces, because any container or crucible of known materials would melt first. Therefore, in the past, molybdenum pieces have been made by compacting moly powder into the desired shape under great pressure, and then passing a high current through the piece to bring its temperature up just below the melting point, so that the particles rigidly adhere to each other. This method has obvious limitations, both as to sizes and shapes.

New processes that remove the restrictions of both size and shape have been developed. The piece can have any desired shape that can be molded. It can be round, square, with fins, angles, or holes, and with much larger over-all dimensions than heretofore possible.

The excellent properties of moly are now available for a variety of uses. The most important characteristics are its high melting point and great wear resistance at elevated temperatures. Also it has a higher modulus of elasticity, increased strength when hot, and better thermal conductivity than any steel. It is lower than the steels in specific heat and coefficient of expansion. Its corrosion resistance compares favorably in many media with tantalum, palladium, and platinum, each costing many times more than moly.

Moly is now proving valuable in the form of crucibles, electronic tube parts, electrical contacts, electrodes for resistance heating of glass welding tips, thermocouple tubes, and for electric furnace heating of elements for high-temperature work in a vacuum or protective atmosphere. It is expected to be useful for welding alloys and high-temperature engine parts.

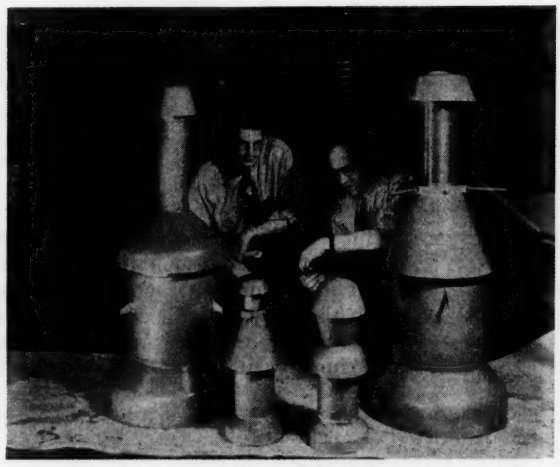
Molecule Pump

The ether—in which there is supposed to be a complete absence of matter—is an interesting hypothesis. It is unobtainable—but engineers have come surprisingly close to it. In the laboratory, with refined equipment, vacuums of one-millionths of a millimeter (10^{-6} mm.) of mercury have been drawn. Sea-level air pressure is 760 million times greater. Pressures down to one-hundredth of a millimeter of mercury (ten microns) are commonly obtainable with rotary-type pumps. Such pressures, regularly maintained in vacuum tubes and mercury-arc rectifiers, have been generally low enough for industrial purposes, before the war anyway. But certain war-production processes—still secret—demanded much lower pressures, and in enormous volumes. Huge pumps capable of drawing vacuums of one-millionth of a millimeter of mercury were required in quantity.

No rotary pumps can do this job alone. Engineers at the Westinghouse Research Laboratories fell back on a pump principle previously known only in laboratories and in very small, special industrial units. It is a pump operating without moving parts on the diffusion principle.

The pump consists of a vacuum-tight cylinder with water-cooling coils on the outside, inside of which is located a jet assembly consisting of one or more jets in series. A pool of oil at the base of the cylinder is heated and the oil vapor passes up through a central pipe in the jet assembly and, on reaching the top, is deflected downward by the jet as a cone-shaped spray against the wall of the cylinder. This wall of downward moving oil vapor traps and carries out the gas molecules from the region above. The oil vapor is then condensed by the water-cooled wall of the outer cylinder and returns to be used over again. The gas has now become concentrated sufficiently so that it can be pumped off by a good rotary pump. Rotary pumps and diffusion pumps are used in series, the rotary pumps doing the large-volume, coarse-vacuum portion of the task while the diffusion pumps carry the vacuum on down to the desired degree.

Before the war, diffusion pumps were small. The four-inch diameter pump was tops in size. Now they are built in sizes eight times larger in diameter.

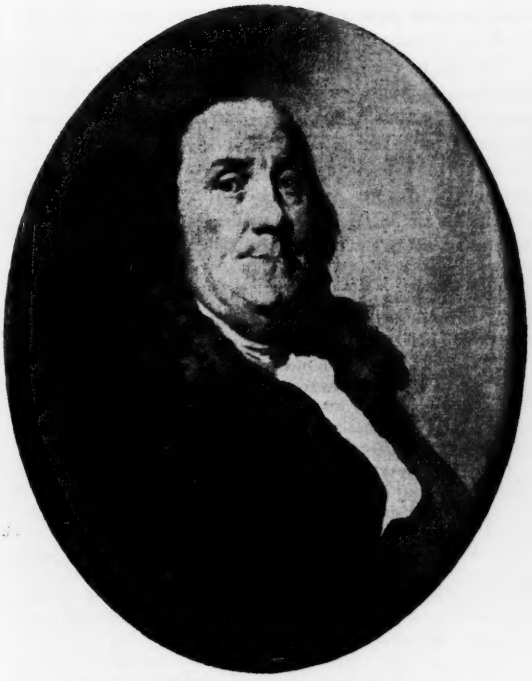


EXTREMELY LOW VACUUMS ARE OBTAINED BY DIFFUSION TYPE PUMPS

Franklin and Lavoisier

H. S. van KLOOSTER

Rensselaer Polytechnic Institute, Troy, New York



PORTRAIT OF FRANKLIN BY J. S. DUPLESSIS

PORTRAIT OF LAVOISIER[1]

IN VIEW of the renewed interest in the life and work of Benjamin Franklin, expressed in recent publications of literary and scientific authors (Carl Van Doren, Nathan G. Goodman, I. B. Cohen, Bernard Jaffe), it may not be amiss to reproduce some epistolary evidences of the contact between America's foremost physicist of the eighteenth century and his French contemporary, Lavoisier. The latter was at the height of his career in the years of Franklin's residence in Paris (1778–86) as diplomatic representative of the United States at the court of Louis XVI. Apart from his official duties Franklin kept up his interest in science by personal contact with noted French scientists, among others the celebrated "Father of Modern Chemistry." An example of the close cooperation of the two men is furnished by the fact that Franklin, together with Lavoisier and three other members of the Academy of Sciences, joined an official investigating committee which was to examine the "animal magnetism" of Friedrich Anton Mesmer and his French disciple, Dr. Deslon. After a study of six months the commission, in September, 1785, rendered a unanimous opinion that no such thing as Mesmer's animal magnetism had been shown to exist. After Franklin's departure from France in July, 1786, he kept up an extensive correspondence with a number of friends in Paris. Several letters of this period have been preserved, among others a letter written to Mad. Lavoisier, a noted artist and the constant collaborator of her gifted husband.

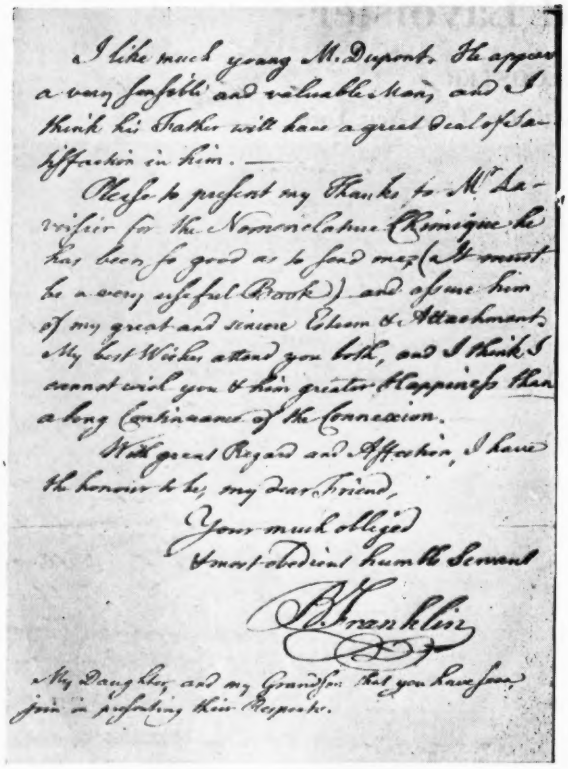
This letter is found on p. 760 of Van Doren's latest book, "Benjamin Franklin's Autobiographical Writings," The Viking Press, New York, **1945.** The writer was fortunate in securing, through the courtesy of Mons. André Léveillé of the Palais de la Découverte in Paris, a facsimile of the original which is kept in the Archives Nationales.

Philadelphia, Oct. 23, 1788.

I have a long time been disabled from Writing to my dear Friend, by a severe Fit of the Gout, or I should sooner have returned my Thanks for her very kind Present of the Portrait, which she has herself done me the honour to make of me. It is allowed by those who have seen it to have great Merit as a Picture in every Respect, but what particularly endears it to me, is the Hand that drew it. Our English Enemies when they were in Possession of this City and of my House, made a Prisoner of my Portrait, and carried it off with them, leaving that of its Companion, my Wife, by itself, a kind of Widow. You have replaced the Husband, and the Lady seems to smile, as well pleased.

It is true, as you observe, that I enjoy here every thing that a reasonable Mind can desire; a Sufficiency of Income, a comfort-

[1] After an engraving by Mlle. Brossard-Beaulieu.



I like much young M. Dupont. He appears a very sensible and valuable Man, and I think his Father will have a great deal of Satisfaction in him. —

Please to present my Thanks to M. Lavoisier for the Nomenclature Chimique he has been so good as to send me (It must be a very useful Book), and assure him of my great and sincere Esteem & Attachment. My best Wishes attend you both, and I think I cannot wish you & him greater Happiness than a long Continuance of the Connexion.

With great Regard and Affection, I have the honour to be, my dear Friend,

Your much obliged
& most obedient humble Servant
B. Franklin

My Daughter and my Grandson that you have seen join in presenting their Respects.

LAST PAGE OF A LETTER FRANKLIN WROTE TO LAVOISIER IN 1788

able Habitation of my own building, having all the Conveniences I could imagine; a dutiful and affectionate Daughter to nurse and take care of me, a number of promising Grandchildren, some old Friends still remaining to converse with, and more Respect, Distinction and public Honours than I can possibly merit;* yet all do not make me forget Paris and the nine Years Happiness I enjoyed there, in the sweet Society of a People, whose Conversation is instructive, whose manners are highly pleasing, and who above all the Nations of the World, have in the greatest Perfection the Art of making themselves beloved by Strangers.—And now, even in my Sleep I find, that the Scenes of all my pleasant Dreams are laid in that City, or in its Neighborhood.

I like much young M. Dupont. He appears a very sensible and valuable Man, and I think his Father will have a great deal of Satisfaction in him.

Please to present my Thanks to M. Lavoisier for the Nomenclature Chimique he has been so good as to send me (It must be a very useful Book), and assure him of my great and sincere Esteem and Attachment. My best Wishes attend you both, and I think I cannot wish you and him greater Happiness than a long Continuance of the Connection.

With great Regard and Affection, I have the honour to be, my dear Friend,

Your much obliged
and most obedient humble Servant
(Signed) B. FRANKLIN

My Daughter and my Grandson that you have seen join in presenting their Respects.

* These are the Blessings of God, and depend on his continued Goodness.

The portrait (by Benjamin Wilson) referred to in this letter was stolen by Captain (later Major) André, the notorious spy, and was taken to England where it remained until 1906, when Lord Grey returned it to the States. It now hangs in the White House. The young Mr. Dupont, mentioned in Franklin's letter, was the older brother, Victor, of Lavoisier's assistant, E. I. du Pont de Nemours, who later (in 1802) established the powder mill which was the origin of the du Pont Company of Delaware.

The high esteem in which Franklin was held by Lavoisier is well exemplified by the letter which Lavoisier, on February 2, 1790, wrote to Franklin, eleven weeks before the latter's death on April 17, 1790. The facsimile of this interesting and instructive letter was obtained through Mons. Léveillé from the Lavoisier collection of Mlle. de Chazelles (a distant relative of Mad. Lavoisier) who was shot by the Germans in 1944.

M. le docteur Francklin
à Philadelphie — Monsieur et très illustre confrère
expéd. le 2 février 1790

M. le Coullens de Coumonc qui retourne en Amérique veut bien se charger de deux exemplaires d'un ouvrage que j'ai publié il y a environ un an sous le titre de traité élémentaire de chimie. Je vous prie de vouloir bien en accepter un et de faire parvenir l'autre à la Société de Philadelphie.

Dans tous les traités de chimie qui ont été publiés depuis Stahl on à toujours commencé par poser une hypothèse et on s'est efforcé ensuite de faire voir qu'avec cette donnée tous les phénomènes de la chimie s'expliquaient passablement bien.

Je crois et un grand nombre de savants pensent aujourd'hui avec moi que l'hypothèse admise par Stahl et modifieé depuis lors est fausse, que le phlogistique dans le sens que Stahl attachait à ce mot n'existe pas et c'est principalement pour développer mes idées à ce sujet que j'ai entrepris le traité que j'ai l'honneur de vous adresser. J'ai cherché comme vous le verrez dans le préface à parvenir à la vérité par l'enchainement des faits; à supprimer le plus qu'il m'a été possible le raisonnement qui souvent est un instrument faux et qui nous trompe pour suivre autant qu'il était possible le flambeau de l'observation et de l' expérience.

Cette marche qui n'avait pas encore été suivie en chimie m'a donné lieu de distribuer mon ouvrage dans un ordre absolument nouveau et la chimie s'est trouvée beaucoup plus rapprochée qu'elle ne l'était de la physique expérimentale. Je désire beaucoup que votre temps et votre santé vous permettent d'en lire les premiers chapitres. Car votre suffrage et celui de quelques savants de l'Europe qui sont sans préjugée dans ces sortes de matières est le seul que j'ambitionne.

Il me semble que la chimie presentée sous cette forme est devenue d'une étude infiniment plus facile qu'elle ne l'était. Les jeunes gens qui n'ont la tête préoccupée par aucun système la saisissent avec avidité mais les anciens chimistes la repoussent encore et la plupart ont même plus de peine à la concevoir et à l'entendre que ceux qui n'ont encore fait aucune étude de la chimie.

Les savants français sont partâges dans ce moment entre l'ancienne et la nouvelle doctrine. J'ai de mon côtè M. de Morveau, M. Berthollet, M. de Fourcroy, M. de la Place, M. Monge, et en général les physiciens de l'Académie. Les savants de Londres et de l'Angleterre abandonnent aussi insensiblement la doctrine de Stahl mais les chimistes allemands y tiennent beaucoup. Voilà donc une révolution qui s'est faite depuis votre départ d'Europe dans une partie importante des connaissances humaines. Je tiendrai cette révolution pour bien avancée et même pour complaitement faite. Si vous vous rangez parmi nous après vous avoir entretenu de ce qui se passe dans la chimie ce sera bien le cas de vous parler de notre révolution politique. Nous la regardons comme faite sans retour. Il existe cependant encore un parti aristocratique qui fait de vains efforts et qui est évidemment le plus faible. Le parti démocratique a de son côté

le plus grand nombre et de plus l'instruction, la philosophie et les lumières. Les personnes modérées et qui ont conservé leur sangfroid dans cette effervescence générale pensent que les circonstances nous ont entrainés trop loin qu'il est fâcheux qu'on ait été obligé d'armer le peuple et tous les citoyens qu'il est impolitique de placer la force entre les mains de ceux qui doivent obéir et qu'il est à craindre que l'établissement de la nouvelle constitution va procréer des obstacles de la part de ceux-même en faveur de ceux pour qui elle a été faite.

Nous sommes arrivés a l'époque la plus importante car on s'occupe dans ce moment par tout le Royaume de la fonction des municipalités. Il parait que les élections se font d'une manière très paisible. Le Royaume sera divisé en 83 départements ou provinces, chaque département en districts, chaque district en cantonments et les cantonments contiendront trois ou quatre municipalités.

Les papiers publiés au surplus vous instruiront de tous les détails.

Nous regrettons bien dans le moment votre éloignement de France; vous auriez été notre guide et vous nous auriez marqué les bornes que nous n'aurions pas dû franchir.

J'ai l'honneur d'être avec un attachement inviolable et respectueux.

Monsieur et très illustre confrère
A. L. LAVOISIER

Doctor Franklin
Philadelphia
February 2, 1790 Sir, and Illustrious Colleague

Mr. le Coullens de Coumonc who returns to America has kindly consented to take along two copies of a treatise which I published a year and a half ago under the title of "Elementary Textbook of Chemistry." I beg you to accept one copy for yourself and one for the Philadelphia Society.

In all chemistry texts published since Stahl it has been customary to propose an hypothesis first and then to try an explanation of chemical phenomena on this basis.

In common with a great number of scientists, I believe that the hypothesis set forth by Stahl and subsequently modified by others is wrong. Phlogiston in the sense of Stahl does not exist, and it is mainly to develop my own ideas on the subject that I have undertaken the treatise which I have the honor to address to you. As you will see from the preface, I have sought to arrive at the truth by a succession of facts, by eliminating, as far as possible, reasoning, which is often a false and deceptive instrument, and by following the torch of observation and experiment.

This procedure, which thus far has not been followed in chemistry, has enabled me to arrange my work in a perfectly new order, whereby chemistry has approached experimental physics much more closely than heretofore.

I sincerely hope that your time and your state of health will permit you to read the first chapters. Indeed, your support and that of some unprejudiced European scientists is all I care for.

It seems to me that chemistry presented in this way is infinitely easier than it was before. Young people whose heads are not preoccupied by any system grasp it avidly, but old-time chemists will reject it, and most of them have more difficulty in grasping and understanding it than those who have not studied any chemistry at all.

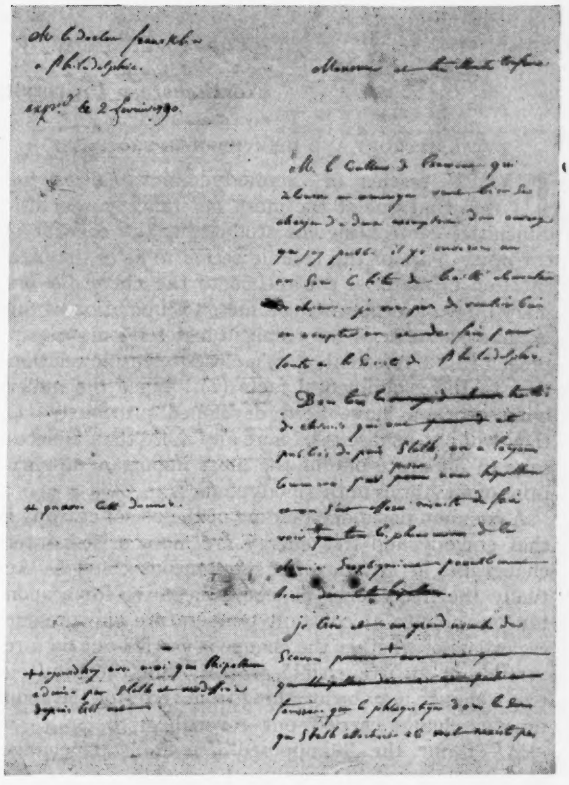
French scientists are divided at present between the old and the new doctrine. On my side, I have Messrs. de Morveau, Berthollet, de Fourcroy, de la Place, Monge, and, generally speaking, the physicists of the Academy. The chemists in London and in England are also dropping Stahl's theory quietly, but German chemists still adhere to it strongly. There is then a revolution in an important branch of human knowledge which has been accomplished since you left Europe. I look upon it as well advanced or even as completely finished. If you take our side after due consideration of what happens in the field of chemistry, it is fitting to speak also of our political revolution.

We consider the latter as irrevocably achieved. There is, however, still an aristocratic party which, although evidently very weak, makes idle efforts. The democratic party is the most numerous and counts educators, philosophers, and other outstanding people among its followers. People of moderation, who have remained level-headed in this general effervescence, think that circumstances have carried us too far and regret the necessity of arming the people and the citizens because it is improper to put force in the hands of those who must obey. They fear that the establishment of the new constitution will create trouble on the part of those for whose benefit it has been made.

We have arrived at the most important epoch of our time, for all over the kingdom the role of the municipalities is being scrutinized. It seems that the elections proceed peacefully. The kingdom will be divided in 83 departments or provinces, these into districts, and each district into subdistricts (cantonments), each containing three or four municipalities. Published papers, moreover, will bring you the complete details. We greatly regret, at the moment, your absence from France: you would have been our guide who would have outlined the boundaries that must not be exceeded.

With my inviolable and respectful attachment, I have the honor to be

Sir, and Illustrious Colleague
A. L. LAVOISIER



FIRST PAGE OF A LETTER LAVOISIER WROTE TO FRANKLIN IN 1790

The picture of Franklin which accompanies this article is a photograph of the painting in the Musée Carnavalet in Paris, made by Duplessis in 1778. This artist painted at least a dozen portraits of Franklin, some of them without sittings. It will be recalled that General De Gaulle on his recent visit to Washington presented President Truman a Duplessis portrait of Franklin.

The Semantics of Thermodynamics. Part II

W. F. LUDER

Northeastern University, Boston, Massachusetts

TOTAL ENTROPY AND IRREVERSIBLE PROCESSES

EVERY teacher of thermodynamics realizes full well that one of the most outstanding semantic difficulties confronting his students is the concept of entropy. Part of the trouble seems to lie in the presentation of material extraneous to the chemist's primary interest in thermodynamics. Elimination of this extraneous material can result in a closer semantic approach to the referrent, *i. e.*, a closer scientific relationship to the experimental facts (*1*). Since the underlying concepts have been developed previously (*1*), they will not be discussed here any more than is necessary to illustrate one of the most important applications of semantics to thermodynamics.

A common misunderstanding of the use of entropy is that entropy and free energy are more or less interchangeable as criteria of a spontaneous change. Actually the free energy change is negative for a spontaneous change at constant temperature and pressure regardless of whether the change is carried out by a reversible or an irreversible process; but the total entropy change may be anything from zero (for the spontaneous change carried out reversibly) to $\Delta S_{\text{total}} = -\Delta F/T$ for the "unopposed" spontaneous change. In general the two are not interchangeable.

As mentioned in the preceding section, a clear understanding of the significance of entropy depends upon a careful distinction between a given *change* and the *method* or *process* by which that change is carried out. It is this distinction that we must emphasize in the following presentation of the meaning of entropy for chemists.

Let us compare two methods of carrying out any *spontaneous change* at constant temperature: first, the reversible process; second, any irreversible process for effecting the given change. Convenient examples to think of would be the two considered in the preceding section. However, the equations developed will be general. For a given spontaneous change

$$\Delta E_r = \Delta E_i \tag{22}$$

for the reversible and the irreversible methods of carrying out the change (since E is a property of the system). Therefore

$$q_r - w_r = q_i - w_i \tag{23}$$

or

$$q_r - q_i = w_r - w_i \tag{24}$$

Now center attention upon any one of the irreversible processes for effecting the given change. w_i is the work actually done when the change is carried out irreversibly. Since w_r is the work which might have been done had the change occurred reversibly,

$$w_r - w_i = \text{energy wasted in the irreversible process at constant temperature} \tag{25}$$

This statement is true only in view of the fact that when heat is evolved at constant temperature, none of it can be converted to work at that temperature according to experience as summarized in the Second Law. Here the reason for adopting the particular statement of the Second Law given in the preceding section becomes obvious.

Remembering that (according to the First Law) if the system produced less work, more heat must have been evolved, we see that

$$\text{extra heat evolved} = \text{energy wasted} \tag{26}$$

in the irreversible process for carrying out the spontaneous change at constant temperature. This *extra* heat evolved cannot be converted to work at constant temperature, because no heat engines exist which will do the job. The less work obtained in the irreversible process, the more energy is wasted, and the greater is the extra heat evolved. We express this more briefly by referring to a process which wastes more of the energy which might have been obtained at constant temperature as being more irreversible.

However, if we wish to have a quantitative measure of irreversibility, we must divide the energy wasted at constant temperature by the absolute temperature. We can understand why this is necessary by comparing changes in which the same amount of extra heat is evolved at two different temperatures. Suppose in the operation of a Daniell cell, the conversion of one mol of zinc to zinc sulfate is accomplished in such a way that 25,000 calories extra heat are evolved first at $T_2 = 300°$A. and second at $T_1 = 280°$A. Some energy could still be salvaged in the first case by operating a heat engine to lower the temperature from 300° to 280°. We can readily see that even though the same heat is evolved, the process is less irreversible at the higher temperature; hence for our measure of irreversibility, we divide by the absolute temperature:

$$\frac{(\text{isothermally wasted energy})_i}{T} = \frac{w_r - w_i}{T} = \frac{q_r - q_i}{T} \tag{27}$$

Either

$$\frac{w_r - w_i}{T}$$

or

$$\frac{q_r - q_i}{T}$$

could be used as a criterion of irreversibility. Since w_r is the *maximum* work

$$\frac{w_r - w_i}{T} > 0 \tag{28}$$

or

$$\frac{q_r - q_i}{T} > 0 \tag{29}$$

Either simple and straightforward equation serves perfectly well as a test for irreversibility. The energy wasted in an irreversible process for carrying out a given spontaneous change at constant temperature divided by the temperature measures the degree of irreversibility of that process at that temperature. The only quantities involved are those for the system itself. The surroundings do not come into the picture at all.

Unfortunately, the historical development of thermodynamics came about quite differently so that we are accustomed to thinking of *total* entropy change (system plus surroundings), which is entirely unnecessary; however, if we regard the equations for entropy change of system and surroundings as merely *abbreviations* for q_r/T and q_i/T, the concept of entropy need cause no trouble.

In equation (27) let

$$q_r/T = \Delta S_{system} \tag{30}$$

Since this quantity is for the reversible process, it always has the same value for a given change, whether that change was actually carried out reversibly or not. Since we are considering an irreversible process, the actual heat effect for the system is q_i. If we wish to consider what effect this q_i has on the surrounding environment, we must remember that heat evolved by the system is heat absorbed by the environment, *i. e.*,

$$-q_i(\text{system}) = +q_i \text{ (environment)} \tag{31}$$

We then define

$$\Delta S_{env.} = q_i/T \tag{32}$$

Unlike ΔS_{system}, this quantity depends upon the degree of irreversibility of the particular process used in carrying out the given change. Contrary to common statements, we can readily see from the preceding discussion that it does not have to be calculated for a reversible process—as does the entropy change of the system.

From equation (27) we may now write

$$\Delta S_{total} = \Delta S_{system} + \Delta S_{env.} = \frac{w_r - w_i}{T} \tag{33}$$

from which we see that for *an irreversible method of carrying out a given spontaneous change at constant temperature, the total entropy change of the system and the environment is equal to the energy wasted in that method divided by the absolute temperature.* This energy could have been used in a reversible process, but was not, so the opportunity has been lost forever. The familiar statement that "the entropy of the universe is increased in an irreversible process" is merely a more abstract way of stating that energy has become isothermally unavailable for doing work.

We have now developed a general but extremely simple method of showing that

$$\Delta S_{total} > 0 \tag{34}$$

for an *irreversible process* at constant temperature. At the beginning of this section the statement was made

TABLE 1

ISOTHERMAL EXPANSION OF ONE MOL OF IDEAL GAS FROM 24.6 TO 36.0 LITERS AT 27°C.

Reversibly	*Irreversibly*
$\Delta E = 0$	$\Delta E = 0$
$w_r = 9.36$ liter-atm.	$w_i = 6.24$ liter-atm.
$q_r = 9.36$ liter-atm.	$q_i = 6.24$ liter-atm.
$\Delta S_{system} = \frac{9.36}{300}$ liter-atm./deg.	$\Delta S_{system} = \frac{9.36}{300}$ liter-atm./deg.
$\Delta S_{env.} = \frac{-9.36}{300}$ liter-atm./deg.	$\Delta S_{env.} = \frac{-6.24}{300}$ liter-atm./deg.
$\Delta S_{total} = 0$	$\Delta S_{total} = \frac{9.36 - 6.24}{300} = \frac{+3.12}{300}$ liter-atm./deg.

TABLE 2

CONVERSION OF ONE MOL OF ZINC IN A DANIELL CELL AT 25°C. AND ONE ATM.

Reversibly	*Irreversibly*
$\Delta E = -51{,}400$ cal.	$\Delta E = -51{,}400$ cal.
$w_r = 51{,}070$ cal.	$w_i = 34{,}047$ cal.
$q_r = -330$ cal.	$q_i = -17{,}353$ cal.
$\Delta S_{system} = \frac{-330}{298}$ cal./deg.	$\Delta S_{system} = \frac{-330}{298}$ cal./deg.
$\Delta S_{env.} = \frac{+330}{298}$ cal./deg.	$\Delta S_{env.} = \frac{+17{,}353}{298}$ cal./deg.
$\Delta S_{total} = 0$	$\Delta S_{total} = \frac{-330 + 17{,}353}{298} = \frac{+17{,}023}{298}$ cal./deg.

that the total entropy change is not in general a criterion for a spontaneous change (as frequently claimed). In order to illustrate the experimental aspects of this statement, let us return to the two examples discussed in the preceding section.

Assume both spontaneous changes to be carried out first reversibly, then irreversibly in such a way that two-thirds the maximum work is realized: 6.24 liter-atm. for the isothermal expansion of the ideal gas and 34,047 cal. for the operation of the Daniell cell. The relevant figures are given in Tables 1 and 2. Note especially how equations (24), (26), and (33) apply. It is immediately obvious in Table 2 that the energy wasted in the irreversible process (method) is 17,353 cal. which is equal to the *extra* heat evolved by the system (*over* the 330 cal. evolved when the change is effected reversibly).*

According to the First Law, any heat evolved in the irreversible process greater than q_r is at the expense of work that might have been done by the system during the spontaneous change (if it had been effected reversibly). The Second Law "forbids" conversion of any of this extra heat into work at constant temperature once it has been evolved.

We now come to the final reason why it is necessary to make a careful semantic distinction between "spontaneous change" and "irreversible process." A glance at Tables 1 and 2 is sufficient. Both are for definite spontaneous changes, yet the total entropy change in each case varies from zero through an indefinitely large number of positive values depending upon how much energy was wasted in the particular method of carrying

* It will be noted that in the expansion of the gas no extra heat is evolved, but instead less is absorbed. These statements, of course, are equivalent, but the words, "extra heat evolved," are used because they more directly apply to most chemical reactions.

out the given change. The wasted energy divided by the temperature measures the degree of irreversibility of that method, *i. e.*, from equation (33)

$$\Delta S_{total} = \frac{w_r - w_i}{T}$$

Therefore we must conclude that the total entropy change measures only the degree of irreversibility of a particular process for effecting a given change. It is not a criterion of the spontaneity of the change.

Chemists must look elsewhere for their test of a spontaneous change.

FREE ENERGY AND SPONTANEOUS CHANGES

The change in free energy which takes place during a given physical or chemical change provides a suitable criterion of its spontaneity. The free energy is defined to be a property of the system, *i. e.*, a characteristic function; therefore, it has the same change in value for a given change regardless of whether the change is carried out reversibly or irreversibly. Here we see again that it is important to understand that the word *process* is used to indicate a particular *method* of effecting a given change.

Customarily the subject of free energy is introduced merely by some such statement as: "Let us define a new function such that $F = H - TS$." Unfortunately this implies an abstraction several times removed from its semantic referrent, *i. e.*, from its scientific basis in experimental data. In order to be more concrete about the meaning of free energy, let us employ another comparison similar to the one used in connection with entropy. When we become more concrete, we find (as the semanticist would have predicted) that the meaning of free energy and its relationship to entropy become much clearer.

Consider any given spontaneous physical or chemical change (using the production of one mol of copper in the reaction of zinc with copper sulfate as an example). Let this spontaneous change take place at constant pressure and temperature unopposed by anything but the pressure of the environment. Under these conditions the net useful work $w' = 0$ in the equation for total work

$$w = w' + p\Delta v \tag{35}$$

For example, when the reaction between zinc and copper sulfate solution is allowed to take place by direct contact between the reagents or when the terminals of a Daniell cell are shorted

$$w' = 0 \tag{36}$$

This "unopposed" change is the most irreversible *method* of effecting the change (under the given conditions), *i. e.*, the most irreversible *process* for carrying out the given spontaneous change.

The total entropy change for such an irreversible process can be calculated as follows. From equation (33) we have

$$\Delta S_{t.u.} = \frac{q_r(\text{system})}{T} + \frac{q_i(\text{env.})}{T} = \frac{w_r - w_i}{T} \text{ (constant } p \text{ and } T)$$

where the subscript *t.u.* is used to indicate "total entropy change when the spontaneous change is unopposed." With the aid of equation (31) this may be rewritten

$$T\Delta S_{t.u.} = q_r - q_i = w_r - w_i \tag{37}$$

where q and w in each case now refer to the system; but under the conditions of constant p and T and $w_i' = 0$, we know that $q_i = \Delta H$ and $q_r = T\Delta S$ so we may write:

$$T\Delta S_{t.u.} = T\Delta S - \Delta H = w_r - w_i \tag{38}$$

Since $w_i' = 0$ we have

$$w_i = w_i' + p\Delta v = p\Delta v \tag{39}$$

so that

$$w_r - w_i = w_r' + p\Delta v - p\Delta v = w_r' \tag{40}$$

and equation (38) becomes

$$T\Delta S_{t.u.} = T\Delta S - \Delta H = w_r' \text{ (constant } p \text{ and } T) \tag{41}$$

where all terms except the first refer to the system. From this equation we see that the increase in isothermally unavailable energy in the most irreversible method of carrying out the given spontaneous change at constant p and T is equal to the net work which might have been obtained if the change had been carried out reversibly.

This wasted energy represents a decrease in isothermally available energy. We designate it by $-\Delta F$, where F is called the free energy and the negative sign indicates a decrease. We may write

$$-\Delta F_{system} = w_r' = T\Delta S_{t.u.} \tag{42}$$

to serve as a definition for ΔF in an unopposed change at constant p and T. Or from equation (41)

$$\Delta F = \Delta H - T\Delta S = -w_r' \text{ (constant } p \text{ and } T) \tag{43}$$

However, the use of this equation is limited. It applies only at constant pressure and temperature; but we note from equation (43) that F is a characteristic function (either from the fact that H or S are both characteristic functions or from the fact that w_r' can have only one value for a given change). This permits us to define F as a property of the system by means of the equation

$$F = H - TS \tag{44}$$

Since F is a property of the system, ΔF for a given physical or chemical change has the same value whether the change is carried out reversibly or irreversibly. This is also obvious from equations (42) and (43). Once the change has occurred, the system can no longer do the work, regardless of whether any work was actually realized during the change. The relationship between the free energy change of the system and the total entropy change may be emphasized by rewriting equation (42) as

$$\frac{-\Delta F_{system}}{T} = \Delta S_{t.u.} \text{ (constant } p \text{ and } T) \tag{45}$$

i. e., the free energy decrease in the system during a given change divided by the temperature is equal to the total entropy increase when the change is carried out by the most irreversible method. Here we have our criterion of a spontaneous change. From equation (45) we see that a decrease in free energy accompanies any spontaneous change at constant p and T.

The free energy change is negative for any spontaneous physical or chemical change at constant pressure and temperature, regardless of whether it is actually carried out by a reversible or an irreversible process. This contrasts with the corresponding statement for entropy: the total entropy change is positive for any irreversible process for effecting a spontaneous change at constant temperature. (A spontaneous change may be carried out irreversibly or reversibly—theoretically and from the thermodynamic viewpoint.)

Before proceeding to experimental illustrations of these conclusions, one other source of confusion for students should be mentioned. The following equation

$$dF = vdp \tag{46}$$

is frequently written without any mention of its limitations, *i. e.*, the conditions for which it applies. Students are prone to forget these restrictions; hence it seems better to present the complete equation and let them simplify it for a particular set of conditions. This may be done (*2*) by differentiating equation (44) which is permissible since it is a characteristic function

$$dF = dH - TdS - SdT \tag{47}$$

and substituting for dH

$$dH = Dq_r + vdp - Dw_r' \tag{48}$$

TABLE 3

ISOTHERMAL EXPANSION OF ONE MOL OF IDEAL GAS FROM 24.6 TO 36.0 LITERS AT 27°C.

Reversibly ($p_{ext} = p$)	*Unopposed* (*expansion into a vacuum, i. e.*, $p_{ext} = 0$)
$\Delta E = 0$	$\Delta E = 0$
$w_r = 9.36$ liter-atm.	$w_i = 0$
$q_r = 9.36$ liter-atm.	$q_i = 0$
$\Delta S_{system} = \frac{9.36}{300}$ liter-atm./deg.	$\Delta S_{system} = \frac{9.36}{300}$ liter-atm./deg.
$\Delta S_{env.} = \frac{-9.36}{300}$ liter-atm./deg.	$\Delta S_{env.} = 0$
$\Delta S_{total} = 0$	$\Delta S_{total} = \frac{9.36}{300}$ liter-atm./deg.
$\Delta F = \int vdp$ (constant T; $Dw_r' = 0$) $= -9.36$ liter-atm.	$\Delta F = \int vdp$ (constant T; $Dw_r' = 0$) $= -9.36$ liter-atm.

TABLE 4

CONVERSION OF ONE MOL OF ZINC IN A DANIELL CELL AT 25° AND 1 ATM.

Reversibly ($\varepsilon = \varepsilon°$)	*Unopposed* ($\varepsilon = 0$; $p = 1$ *atm.*)
$\Delta E = -51{,}400$ cal.	$\Delta E = -51{,}400$ cal.
$w_r = 51{,}070$ cal.	$w_i = 0$ (assuming no volume change)
$q_r = -330$ cal.	$q_i = -51{,}400$ cal.
$\Delta S_{system} = \frac{-330}{298}$ cal./deg.	$\Delta S_{system} = \frac{-330}{298}$ cal./deg.
$\Delta S_{env.} = \frac{+330}{298}$ cal./deg.	$\Delta S_{env.} = \frac{+51{,}400}{298}$ cal./deg.
$\Delta S_{total} = 0$	$\Delta S_{total} = \frac{-330}{298} + \frac{51{,}400}{298} = \frac{51{,}070}{298}$ cal./deg.
$\Delta F = -\int Dw_r' = -w_r'$ (const. p, T) $= \Delta H - T\Delta S$ $= -51{,}070$ cal.	$\Delta F = \int Dw_r' = -w_r'$ (const. p, T) $= \Delta H - T\Delta S$ $= -51{,}070$ cal.

This is equation (4) for a reversible change so that Dq_r can be used to cancel TdS in equation (47). We obtain

$$dF = -Dw_r' + vdp - SdT \tag{49}$$

the general differential equation for free energy change.

We now return to our two spontaneous changes previously considered. Table 3 gives data for the physical change and Table 4 gives the corresponding data for the chemical change. Both are carried out first by a reversible process and then by the most irreversible process under the given conditions. The ideal gas is allowed to expand into an evacuated tank of the proper size to make the final volume 36.0 l. The Daniell cell is assumed to be set up with such large amounts of copper sulfate and zinc sulfate solutions (activities equal to one) that no appreciable change in concentration occurs when a mol of zinc is used up.

In Table 3 equation (49) reduces to $\Delta F = \int vdp$ because the temperature is constant and there is no net work (work other than pv work) during the expansion of a gas. The pressure in the vdp term is the pressure of the gas. In Table 4 equation (49) reduces to $\Delta F = \int Dw_r'$ because both p and T are constant; or the other form $\Delta F = \Delta H - T\Delta S$ may be used since these are the conditions under which it was derived. Note that for both spontaneous changes

$$-\Delta F = T\Delta S_{t.u.}$$

i. e., the decrease in free energy of the system equals the total increase in entropy times the temperature when the change takes place by the most irreversible process.

These tables provide a concrete illustration of the semantic necessity of distinguishing between a given change and the particular process by which the change is carried out. They show that in a given spontaneous change:

Carried out reversibly $\begin{cases} \Delta S_{total} = 0 \\ \Delta F_{system} = -\text{ cal.} \end{cases}$

Carried out irreversibly $\begin{cases} \Delta S_{total} = +\text{ cal./deg. up to } -\Delta F/T \\ \Delta F_{system} = -\text{ same number cal. as reversibly} \end{cases}$

ΔF_{system} has only one value for a given change, while ΔS_{total} has any value from 0 to $-\Delta F/T$ depending upon the irreversibility of the process used for effecting the given change. Yet we find most writers (including myself until now) using "spontaneous change" and "irreversible process" synonymously. No wonder thermodynamics is so difficult for the poor student!

THE MEANING OF F AND S AS PROPERTIES

One more important semantic difficulty remains: the meaning of the functions F and S as properties of a given system. It is fairly easy to grasp the significance of ΔF and ΔS manifest in physical or chemical changes as discussed above. It is more difficult to understand and to explain the intrinsic properties. The following discussion is not intended to be thermodynamically rigorous, but rather to convey merely a *feeling* for the

meaning of the entropy and free energy in a system. As before when considering the meaning of E and H, we find it desirable to depart from "pure" thermodynamics.

For a concrete illustration, take the reaction

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2 \quad (50)$$

We shall try to visualize the free energy and entropy as properties of one mol of each of the four substances. For example, the free energy change during the reaction may be represented by the equation:

$$\Delta F = F_{ZnCl_2} + F_{H_2} - F_{Zn} - 2F_{HCl} \quad (51)$$

Now each F is defined by equation (44) which we rearrange to read

$$H = F + TS \quad (52)$$

As has already been explained, H may be regarded as the total energy in a mol of each substance:

$$H = E + pv \quad (53)$$

Obviously we may combine (52) and (53):

$$E + pv = F + TS \quad (54)$$

But the internal energy may be divided into potential and kinetic energy

$$E = E_f + E_k \quad (55)$$

where

E_f = potential energy, due largely to electrical forces between the particles of the substance

and

E_k = kinetic energy, due to disordered motion of the particles in the substance (translational, vibrational, etc.)

Substituting (55) into (54):

$$E_k + (E_f + pv) = F + TS \quad (56)$$

pv is grouped with E_f because it is also potential energy. As we consider this equation, we naturally suspect that the right-hand side might also be broken up into potential and kinetic energy. When we remember the kinetic meaning of temperature, we are inclined to the idea that TS corresponds to E_k, the kinetic energy of the system; therefore we associate F with the potential energy of the system and write:

$$F = E_f + pv = \text{potential energy}\dagger \quad (57)$$

$$TS = E_k = \text{kinetic energy of disordered motion} \quad (58)$$

Equation (52) merely states a self-evident fact: the total energy in a mol of a substance is equal to the sum of the kinetic and potential energies. When a chemical reaction takes place, the change in total energy is, using equation (50) as an example,

$$\Delta H = H_{ZnCl_2} + H_{H_2} - H_{Zn} - 2H_{HCl} \quad (59)$$

but in terms of potential and kinetic energies,

$$\Delta H = \Delta F + \Delta(TS) \quad (60)$$

† Most readers will recognize E_f as the familiar A. This quantity has not been discussed because it is so seldom used in practice.

Each substance has a *different* value of H (total energy) made up of the sum of *different* values of F (potential energy) and TS (kinetic energy). Therefore when a chemical reaction takes place there will be in general a net gain or loss in all three quantities.

Remembering the physical principle of maximum stability at minimum potential energy, we can now readily understand why it is that the decrease in free energy measures the driving force in a chemical reaction. A decrease in free energy of the system is a reduction in total potential energy of the system. The sum of the potential energies of the products is less than the sum of the potential energies of the reactants.

Examining equation (58) to determine the meaning of the entropy as a property of a substance, we recall that any energy term can be written as the product of an intensity factor and a capacity factor, *e. g.*,

$$w = f \cdot s$$

$$w = \varepsilon \cdot Q$$

$$w = p \cdot \Delta v$$

where f, ε, and p are the intensity factors. The intensity factors determine the direction of the motion: of a body, of a charge, or of a change in volume in the above equations. Since the temperature determines the direction of the transfer of kinetic molecular energy when two bodies are in contact, we conclude that T is the intensity factor and S is the *capacity factor* of the kinetic energy of disordered motion in a substance.

An analogy between the pv and TS energy of a substance may be helpful:

$$\underset{\text{(volume energy)}}{pv} = \underset{\text{(mobilizer)}}{p} \times \underset{\text{(amount of volume)}}{v}$$

$$\underset{\text{(disorder energy)}}{TS} = \underset{\text{(mobilizer)}}{T} \times \underset{\text{(amount of disorder)}}{S}$$

When a reversible change occurs in the volume of a system at constant pressure, a corresponding change in the volume energy of the system must take place:

$$Dw_r = pdv \quad (61)$$

When a reversible change occurs in the amount of disorder in a system at constant temperature, a corresponding change in the disordered energy of a system must take place:

$$Dq_r = TdS \quad (62)$$

We are now back to the original definition of entropy change of a system:

$$dS = Dq_r/T \quad (63)$$

On our circuit we have seen that entropy as a property of a substance is the capacity factor of the kinetic energy of disordered motion among the particles of the substance. It is a measure of the amount of disorder in the substance.

However, so far as the chief application of entropy in chemistry is concerned, we need only use it in the sense of equation (63) as an abbreviation for Dq_r/T for the system or Dq_i/T for the surroundings when a

chemical change occurs. The relationship follows:

$$T\Delta S_{total} = q_r - q_i = w_r - w_i$$

= isothermally wasted energy

THE VALIDITY OF THE LAWS OF THERMODYNAMICS

The two laws of thermodynamics have been expressed by some as broad generalizations, *e. g.*, "The Energy of the Universe remains constant; the Entropy of the Universe is continually increasing." When stated in such form, their validity is open to serious question, both from the semantic and scientific viewpoints. Such a statement may be true, but we have no means of testing it at present. In fact, recent discoveries throw considerable doubt upon it.

The whole question of "Entropy, Chemistry, and Cosmology" will be discussed in a subsequent paper. Here it will be sufficient to point out that energy is being created out of matter in the stars with an accompanying decrease in entropy. For example, according to Bethe (*3*) the sun's energy is due to the transformation of hydrogen into helium. This is a decrease in the disorder of the sun, hence a decrease in entropy. The difference between the mass of four hydrogen atoms and one helium atom appears as newly created radiant energy.

The cosmology of E. A. Milne (*4*) also casts doubt upon the universal application of the "laws" of thermodynamics. According to Milne's analysis of the expanding universe, the universe is not running down as many physicists of the nineteenth century maintained.

In spite of these cosmological doubts as to their validity, however, we may still say that the laws of thermodynamics are good for ordinary chemistry on the earth. No exceptions have yet been found to occur in the familiar reactions which do not involve subatomic phenomena. So as chemists we may continue to use them with confidence—if we state them in a properly limited form.

CONCLUSION

Semantic analysis of thermodynamics leads to two interesting results.

First, it confirms the premise of the semanticist that many of our trials and tribulations are due to our carelessness in the use of words. This carelessness leads to hazy thinking on our part as users and teachers of thermodynamics. It also makes the subject much more difficult to present to students.

Second, semantic analysis leads to helpful conclusions, several of which have been tentatively set forth in this article. They are:

1. In thermodynamics, the semantic search for the referrent becomes equivalent to the scientific aim of basing terminology as closely as possible upon the experimental facts.

2. A different symbol should be used in the differential equations to emphasize the difference between E and H on the one hand and q and w on the other.

3. The function H should never be called "heat content." There is no heat in a system. Total energy is better from the semantic viewpoint.

4. For chemists the Second Law should be stated in the form most directly applicable to the chemist's primary interest in thermodynamics, *i. e.*, equilibrium conditions. Some statements of the Law are open to objection because they claim too much; they are not descriptions of the facts as we know them. A simple statement of our observations on heat engines is better semantics *and* better science. Such a statement will not have to be retracted in view of the expansion of the universe—or because of any other later discovery.

5. A clear distinction between "spontaneous change" and "irreversible process" is necessary. "Process" refers to the method by which a given change is carried out.

6. The total entropy change is merely a criterion of an irreversible process, not of a spontaneous change. Actually the idea of entropy is unnecessary in chemical thermodynamics. Either of the terms

$$\frac{q_r - q_i}{T} \text{ or } \frac{w_i - w_r}{T}$$

could be used without referring to total entropy change (to which they are both equal).

7. The free energy change is the criterion of a spontaneous change at constant pressure and temperature. It is the same for a given change regardless of whether the change is carried out reversibly or irreversibly. This is evident from the defining equation

$$-\Delta F = w_r' = T\Delta S_{t.s.} \text{ (constant } p, T)$$

The total entropy change is useless for such a criterion because it may vary from zero to $-\Delta F/T$ depending upon how irreversibly the change is effected.

8. The habitual use of the complete differential equation

$$dF = -Dw_r' + vdp - SdT$$

is preferable to limited forms of it such as

$$dF = vdp$$

The limitations are too easily forgotten.

9. The derivation of the equations

$$F = E_f + pv = \text{potential energy}$$

$$TS = E_k = \text{kinetic energy of disordered motion}$$

is helpful in understanding the meaning of the free energy and entropy as properties of a system.

10. More frequent tying down of the definitions and ideas used in thermodynamics is desirable. Some concrete experimental examples have been suggested.

Comment on and criticism of the ideas expressed in this paper will be welcomed.

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Chemical Russian, Self-taught

III. Russian Inorganic Chemical Nomenclature

JAMES W. PERRY

Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland[1]

The Russian inorganic chemical nomenclature is reviewed with particular attention to certain peculiarities which may prove troublesome to English speaking chemists. The Russian nomenclature of the more common, relatively simple, inorganic compounds is emphasized. Russian authors of chemical papers do not hesitate to use formulas for more unusual, highly complicated compounds, thus obviating the nomenclature problem in such cases.

SOME FUNDAMENTAL CONSIDERATIONS

THE Russians, like ourselves, have special names for certain compounds, such as **каломель**, calomel **аммиак**, ammonia, etc.; however, the multiplicity of inorganic compounds makes it impractical to have a special name for each compound. Consequently, the Russians, like ourselves, make extensive use of the principle that the name of a compound shall indicate its chemical composition. In deriving the names of compounds from the names of component elements, the Russians use several different grammatical devices. Thus they may use suffixes and prefixes to denote different states of chemical combination similar to our use of sulfurous, sulfate, hyposulfite, bisulfite (derived from the root, sulf-, of the noun, sulfur). The Russians also use compound words corresponding to phosphomolybdate, chloroplatinate, etc. The Russians, like ourselves, make particularly extensive use of word combinations, *e. g.*, sodium chloride, bicarbonate of soda, ferric chloride, perchloric acid.

The Russians, however, carefully avoid using one noun to modify another, as in "sodium chloride." In naming this simple compound, the Russians may convert the root word, **хлор** (chlorine), into an adjective by affixing a suffix and a grammatical ending and then using the adjective to modify the noun, **натрий** (sodium). Thus we have **хлористый натрий**, NaCl. An alternate name is the literal equivalent of "chloride of sodium." By transliterating "chloride" into Russian letters we have **хлорид**. The genitive singular of **натрий** is **натрия**. By combining these two, we have **хлорид натрия**, NaCl. This dual nomenclature system is used quite extensively by the Russians. English-speaking chemists probably encounter more difficulties in understanding that branch of the Russian nomenclature system which uses suffixes to convert nouns into adjectives, as in **хлористый натрий**.

Before undertaking to review such difficulties, it is necessary to point out the need for making a careful distinction between suffixes and inflectional endings. For example, by affixing to the *root*, **хлор**, the *suffixes*, **-н-** and **-ист-**, the *stems* of two adjectives, **хлорн-** and **хлорист-**, are formed. As discussed subsequently these two adjectives are used to indicate different valence states. When Russian adjectives are used in phrases and sentences, inflectional *endings* are affixed to the stems of the adjectives. Such inflectional endings change according to the case, number and gender of the nouns which the adjectives modify. For example, the above mentioned adjectives take the following forms in the nominative singular.

Masculine	*Feminine*	*Neuter*
хлорный	**хлорная**	**хлорное**
хлористый	**хлористая**	**хлористое**

The case endings, **-ый**, **-ая**, **-ое**, have purely grammatical significance and indicate nothing as to valence states

Similarly, the endings of nouns change depending on the case. The following examples illustrate the singular number of the declension of adjectives and nouns:

	Masculine	*Feminine*	*Neuter*
Nom.	**хлорный хром**	**хлорная медь**	**хлорное олово**
Gen.	**хлорного хрома**	**хлорной меди**	**хлорного олова**
Dat.	**хлорному хрому**	**хлорной меди**	**хлорному олову**
Acc.	**хлорный хром**	**хлорную медь**	**хлорное олово**
Instr.	**хлорным хромом**	**хлорной медью**	**хлорным оловом**
Prep.	**хлорном хроме**	**хлорной меди**	**хлорном олове**
	$CrCl_3$	$CuCl_2$	$SnCl_4$

The grammatical significance of inflectional endings is outside the scope of this paper.

Subsequent discussion mentions various chemical elements, whose Russian names are listed for reference purposes. Note that, in Russian, the names of the elements may be classified according to their grammatical gender.

Masculine		**магний**	Mg	**хром**	Cr
азот	N	**марганец**	Mn	**цинк**	Zn
алюминий	Al	**мышьяк**	As		
барий	Ba	**натрий**	Na	*Feminine*	
бор	B	**свинец**	Pb	**медь**	Cu
бром	Br	**селен**	Sn	**платина**	Pt
ванадий	V	**стронций**	Sr	**ртуть**	Hg
водород	H	**талий**	Tl	**сера**	S
иод	I	**титан**	Ti	**сурьма**	Sb
иридий	Ir	**торий**	Th		
калий	K	**углерод**	C	*Neuter*	
кальций	Ca	**уран**	U	**железо**	Fe
кобальт	Co	**фосфор**	P	**золото**	Au
кремний	Si	**фтор**	F	**олово**	Sn
литий	Li	**хлор**	Cl	**серебро**	Ag

[1] Present address, Massachusetts Institute of Technology, Cambridge, Massachusetts.

RUSSIAN NOMENCLATURE OF VARIOUS TYPES OF COMPOUNDS

(*a*) *Oxides of Metals.* The following examples illustrate Russian usage in naming metal oxides most of which have basic properties.[2] Note the use of alternate names[3] for some of these oxides.

окись магния MgO
окись серебра Ag_2O
окись натрия Na_2O
перекись натрия Na_2O_2
закись меди Cu_2O
окись меди CuO
закись железа FeO
окись железа Fe_2O_3
закись марганца MnO
окись марганца Mn_2O_3
перекись марганца, двуокись марганца } MnO_2
перекись водорода H_2O_2
окись цинка ZnO
окись алюминия Al_2O_3
закись олова SnO
окись олова, двуокись олова } SnO_2
закись талия Tl_2O
окись талия Tl_2O_3
закись ртути Hg_2O
окись ртути HgO
недокись свинца Pb_2O
окись свинца PbO
перекись свинца PbO_2
перекись кальция CaO_2

The following generalities are important:

(1) The different valence states of the metals in oxides may be denoted by attaching various prefixes to the root, -кис-.

(2) If a metal forms only one oxide of salt forming, basic character, the oxide is termed окись.

(3) If a metal forms two oxides having basic properties, the lower oxide is termed, закись, and the higher oxide, окись.

(4) A peroxide is usually termed перекись, although the term, надокись, may be used sometimes.

(5) The term, недокись (suboxide), is rarely used.

(6) In the examples listed above, the nouns, недокись, закись, окись, перекись, are in окись all in the nominative singular case (case ending -ь), while the nouns denoting the various metals are all in the genitive singular case.

(7) Prefixes derived from numerals, *e. g.*, дву-, di- (from два, two) are used by the Russians in much the same way as in our nomenclature system. Further examples illustrating this point will be given in discussing other classes of compounds.

(*b*) *Some Typical Salts Consisting of Two Elements.* The following examples illustrate typical Russian nomenclature[4] of compounds of metals with various electronegative elements. It should be noted that the Russian name of each of these compounds consists of an adjective followed by a noun. The noun in each case denotes the metal. Both adjective and noun as listed below are in the nominative, singular case.

фтористый натрий NaF
хлористый торий $ThCl_4$
бромистый кальций $CaBr_2$
иодистый алюминий AlI_3
сернистый натрий Na_2S
пятисернистый натрий Na_2S_5
многосернистый натрий Na_2S_x
хлористое золото $AuCl$
хлорное золото $AuCl_3$
сернистый свинец PbS
сернистое серебро Ag_2S
сернистая медь Cu_2S
серная медь CuS
хлористое железо $FeCl_2$
хлорное железо $FeCl_3$
хлористый талий $TlCl$
хлорный талий, трехххлористый талий } $TlCl_3$
бромистая ртуть $HgBr$
бромная ртуть $HgBr_2$
хлористое олово, полухлористое олово } $SnCl_2$
хлорное олово, четыреххлористое олово } $SnCl_4$
хлористая сурьма, трехххлористая сурьма } $SbCl_3$
хлорная сурьма, пятихлористая сурьма } $SbCl_5$

Note the following important generalities:

(1) In compounds, *which consist of a metal and a single electronegative element,* the valence state of the metal may be indicated either by the use of a suffix (-ист-[5] or -н-) or by a prefix (полу-, semi-; одно-, mono-; дву-,[6] di-; трех-, tri-; четырех-, tetra-; пяти-, penta-) affixed to the adjective denoting the electronegative element. These prefixes (and also много-, poly-) may also be used in naming compounds, *e. g.*, Na_2S_5, Na_2S_x, which differ with respect to composition but not with respect to the valence state of the metal.

(2) When so used, the pair of suffixes -н- and -ист- indicate, respectively, the higher and lower valence states of the metal.

(3) The suffix -ист- is used when there is no need to indicate different valence states of the metal (*e. g.*, $NaCl$, AlI_3) or when such valence state is indicated by a prefix (*e. g.*, пяти-, penta-). This is a very important point and will be referred to again.

(*c*) *Other Compounds Consisting of Two Elements.* The following examples further illustrate typical Russian nomenclature involving word combinations consisting of an adjective and a noun. Note, in particular, the frequent use of the suffix, -ист-,[5] to form adjectives from nouns.

хлористый кремний $SiCl_4$
иодистый водород HI
водородистый натрий NaH
трехсернистый фосфор P_2S_3
пятисернистый фосфор P_2S_5
фосфористый кальций Ca_3P_2
азотистый титан Ti_3N_4
хлористый фосфор, трехххлористый фосфор } PCl_3
хлорный фосфор, пятихлористый фосфор } PCl_5
хлористый азот NCl_3
хлористая сера S_2Cl_2
углеродистый кремний SiC
трехфтористый бром BrF_3
пятифтористый бром BrF_5

(*d*) *Acids Containing Oxygen.* The Russian names of acids containing oxygen consist of the noun, кислота

[2] Various metal oxides which function as acid anhydrides will be discussed after considering the corresponding acids.

[3] Various other alternate names will be mentioned subsequently.

[4] Alternate names for some of these compounds will be discussed subsequently.

[5] Note that the suffix, -ист-, is used in the alternate form, -нист-, in сернистый.

[6] An alternate form, двух-, is sometimes encountered.

(acid), preceded by an adjective whose suffix may denote the state of oxidation of the acid forming element. The following examples are important and typical although some of the acids are unstable or hypothetical.

хлорноватистая кислота $HClO$
хлористая кислота $HClO_2$
хлорноватая кислота $HClO_3$
хлорная кислота $HClO_4$
серноватистая кислота $H_2S_2O_4$ *Cf. (3) below.*
сернистая кислота H_2SO_3
серная кислота H_2SO_4
мононадсерная кисдота / моноперсерная кисдота } H_2SO_5
надсерная кислота $H_2S_2O_8$
селенистая кислота H_2SeO_3
селеновая кислота H_2SeO_4
фосфорноватистая кислота H_3PO_2
фосфористая кислота H_3PO_3
фосфорноватая кисдота $H_4P_2O_6$
фосфорная кислота / or, more precisely, / орто-фосфорная кислота } H_3PO_4
мета-фосфорная кислота HPO_3
пиро-фосфорная кислота $H_2P_2O_7$
мышьяковистая кислота H_3AsO_3
мышьяковая кислота H_3AsO_4
азотноватистая кислота $H_2N_2O_2$
азотистая кислота HNO_2
азотная кислота HNO_3
марганцовистая кислота H_2MnO_4
марганцовая кислота $HMnO_4$
орто-титановая кислота H_4TiO_4
мета-титановая кислота H_2TiO_3
хромовая кислота H_2CrO_4
двухромовая кислота $H_2Cr_2O_7$
мононадхромовая кислота / моноперхромовая кисдата } $HCrO_5$
тринадхромовая кисдота / триперхромовая кисдота } H_2CrO_8
ванадиевая кислота / or, more precisely, / орто-ванадиевая кислота } H_3VO_4
железистая кислота $HFeO_2$
железная кислота H_2FeO_4
наджелезная кислота H_2FeO_5
угольная кислота H_2CO_3

Note the following generalities:

(1) The suffixes, -новатист-, -ист- (or -нист- or -овист-), -новат-, and -н- (or, less generally, -ов- or -ев-) are used in that order to denote successively higher states of oxidation of the acid forming element.

(2) All the members of this series of suffixes are not required when naming the acids derived from certain elements.

(3) The name, серноватистая кислота, is often used for $H_2S_2O_3$ although, as pointed out in a recently published dictionary (*3*), it is more logical to refer to $H_2S_2O_3$ as тиосерная кисдота (thiosulfuric acid). In this connection note the following:

дитионовая кислота $H_2S_2O_6$
тетратионовая кислота $H_2S_4O_6$

(4) The prefixes, над- and пер-, are used in naming *per-* acids.

(*e*) *Acid Anhydrides.* The suffixes used in naming acids containing oxygen are also used in naming the corresponding anhydrides. Note, however, that the noun, ангидрид, is masculine, while кислота is feminine. Consequently, the inflectional endings of adjectives used with кислота and ангидрид are different. The following list includes a few oxides which are not acid anhydrides. Examples of alternate names are included in some cases.

сернистый ангидрид / двуокись серы } SO_2
серный ангидрид / трехокись серы / перекись серы S_2O_7 } SO_3
селенистый ангидрид SeO_2
селеновый ангидрид SeO_3
марганцовистый ангидрид Mn_2O_3
марганцовый ангидрид / семиокись[7] марганца } Mn_2O_7
мышьяковистый ангидрид / трехокись мышьяка } As_2O_3
мышьяковый ангидрид / пятиокись мышьяка } As_2O_5
ванадиевый ангидрид / пятиокись ванадия } V_2O_5
закись азота N_2O
окись азота NO
азотистый ангидрид N_2O_3
двуокись азота NO_2
азотноватый ангидрид N_2O_4
азотный ангидрид N_2O_5
титановый ангидрид / двуокись титана } TiO_2
угольный ангидрид / углекислый газ / двуокись углерода } CO_2
окись углерода CO
закись железа FeO
окись железа Fe_2O_3
закись-окись железа Fe_3O_4
наджелезный ангидрид FeO_4

(*f*) *Salts of Oxygen Containing Acids.* The Russians may use several different methods to name the salts of acids containing oxygen. The most important Russian method for deriving the names of such salts, *e. g.*, Na_2SO_4, might be considered to consist of the following steps. Starting with the name of the acid (*e. g.*, серная кислота, H_2SO_4) the letter -о- is attached to the *stem* of the adjective used in naming the acid. Thus one obtains серно- to which the stem of the name of the metal is now added, to form, in our example, сернонатри-. To this is now added a further *suffix*, which is usually either -ов- or -ев- if the metal forms only one series of salts corresponding to a single valence state. Thus the *stem* of an adjective, *e. g.*, сернонатриев-, is formed. This adjective together with the proper grammatical ending is used to modify the noun, соль (salt). Thus the nominative case of one Russian name for Na_2SO_4 is сернонатриевая соль.

If the metal forms salts corresponding to two different valence states, the same procedure may be followed with this difference. The *suffix* -ов- (or its equivalent, -ев-) is not used. Instead the *suffix* -н- is used to denote the higher valence state, while -ист- is used for the lower valence state.

The following examples illustrate the names of salts derived from acids containing oxygen.

хлорноватистокальциевая соль $Ca(ClO)_2$
хлористолитиевая соль $LiClO_2$

[7] Here the prefix, семи-, denotes hepta- rather than semi-.

хлорноватокалиевая соль $KClO_3$
хлорнобариевая соль $Ba(ClO_4)_2$
серножелезная соль $Fe_2(SO_4)_3$
серножелезистая соль $FeSO_4$
сернистостронциевая соль $SrSO_3$
надсерноаммониевая соль $(NH_4)_2S_2O_8$
сернокальциевая соль $CaSO_4$
железистонатриевая соль $NaFeO_2$
железнокалиевая соль K_2FeO_4
наджелезнокалиевая соль K_2FeO_5

It should be noted that the procedure described above is not followed in full detail in naming certain salts. Thus, for example:

углесеребряная соль Ag_2CO_3
but угольная кислота H_2CO_3
серебро Ag
сернооловянистая соль $SnSO_4$
but олово Sn

Care should be used in distinguishing the above mentioned *adjectives*, used in naming salts, from compound *nouns* of the following type.

углеводород hydrocarbon
угдевод carbohydrate
феррохром ferrochrome
сероводород H_2S
сероуглерод CS_2
селеноводород H_2Se

(*g*) *Alternate Russian Nomenclature.* The preceding discussion has reviewed the Russian nomenclature commonly used for some of the most important classes of inorganic compounds. It should be pointed out, however, that the Russians may use alternate methods for naming inorganic compounds.

One alternate method for naming Na_2SO_4 or similar salts of acids containing oxygen, starts with the name of the acid, *e. g.*, серная кислота, H_2SO_4. As before, the letter -о- is attached to the *stem* of the adjective used in naming the adjective, *e. g.*, серно-. To this the *root* кис- and the *letter* -л- are added to form сернокисл-. This is the *stem* of an adjective which is used to modify the name of the metal contained in the salt. Thus we have сернокислый натрий, Na_2SO_4. Note also the following additional examples:

бромноватистокислый аммоний NH_4BrO
хромовокислый калий K_2CrO_4
пиро-мышьяковокислый магний $Mg_2As_2O_7$
углекислый литий Li_2CO_3

Another method occasionally used for naming salts is to construct a phrase consisting of (1) an adjective used to name the acid involved, (2) the word, соль (salt), and (3) the genitive case of the name of the metal oxide from which the salt may be considered to be derived.

азотная соль окиси ртути $Hg(NO_3)_2$
сернокислая соль окиси железа $Fe_2(SO_4)_3$
сернокислая соль закиси железа $FeSO_4$
азотнокислая соль закиси ртути $HgNO_3$

Similarly derived alternate names may be encountered at times, as illustrated by the following examples, whose further discussion does not appear profitable.

азотнокислая закись ртути
азотнортутная соль закиси ртути
закисная азотнортутная соль
закисная ртутная соль азотной кислоты
} $HgNO_3$

двуазотная ртуть
азотнокислая окись ртути
азотнортутная соль окиси ртути
ртутная соль азотной кислоты
} $Hg(NO_3)_2$

Russian authors sometimes use *numerals* (either Arabic or Roman) to designate different valence states of metals. This simple, unambiguous method of designating valence states has been proposed for official adoption (*1*).

окись железа (2) FeO
окись железа (3) Fe_2O_3
окись железа (2,3) Fe_3O_4
бромистое железо (2) $FeBr_2$
бромистое железо (3) $FeBr_3$
азотнокислое железо (2) $Fe(NO_3)_2$
азотнокислое железо (3) $Fe(NO_3)_3$
окись меди (1) Cu_2O
сернокислая медь (1) Cu_2SO_4
фтористая медь (2) CuF_2
азотнокислая медь (2) $Cu(NO_3)_2$
цианистая медь (2,3) $Cu_2(CN)_2 \cdot Cu(CN)_2$

A widely used and consequently important alternate method for naming salts is similar in some respects to our own nomenclature. The following examples illustrate this point. Note that the Russian names of the acid radicals might be regarded as transliterations of the corresponding English terms.

азид свинца $Pb(N_3)_2$
хлорид калия KCl
сульфат натрия Na_2SO_4
иодат натрия $NaIO_3$
цианид кальция $Ca(CN)_2$
перкарбонат натрия $Na_2C_2O_6$
перборат натрия $NaBO_3$
трифосфат натрия Na_3PO_4
дитионат натрия $Na_2S_2O_6$
тетратионат натрия $Na_2S_4O_6$
арсенат кобальта $Co_3(AsO_4)_2$
тиоарсенат натрия Na_3AsS_4
метасиликат натрия Na_2SiO_3
алюминат натрия
or, more precisely
ороталюминат натрия
} Na_3AlO_3
метаалюминат натрия $NaAlO_2$
перманганат калия $KMnO_4$
бихромат калия $K_2Cr_2O_7$
сульфгидрат натрия NaSH
сульфид окисного золота
сульфид золота (3)
} Au_2S_3
сульфид закисного золота
сульфид золота (1)
} Au_2S
сульфат окиси железа
сульфат железа (3)
} $Fe_2(SO_4)_3$
сульфат закиси железа
сульфат железа (2)
} $FeSO_4$
феррит натрия $NaFeO_2$
фосфомолибдат аммония $(NH_4)_3PO_4 \cdot 12MoO_3 \cdot 6H_2O$

Similarly:

карбид кальция CaC_2
нитрид магния Mg_3N_2

Alternate names for simple inorganic acids are rarely encountered.

нитритная кислота HNO_2
нитратная кислота HNO_3
сульфитная кислота H_2SO_3
гипофосфористая кислота H_3PO_2
гипофосфорная кислота $H_4P_2O_6$

(*h*) *Complex Compounds of the Werner Type.* As a rule, Russian chemists prefer to use formulas to designate complex compounds of the Werner type; however, names may be used at times as illustrated below. Note that there is a pronounced tendency for the Russians to adopt foreign nomenclature when naming this type of compound.

хлориридат натрия Na_2IrCl_6
хлориридит натрия Na_3IrCl_6
кремнефтористый калий K_2SiF_6
кобальтоазотистокалиевая соль $K_3Co(NO_2)_6$
кобальтосинеродистый калий $K_3Co(CN)_6$
хлорплатинат калия K_2PtCl_6
серебряносинеродистый натрий $NaAg(CN)_2$
золотохлористокалиевая соль, хлораурат калия } $KAuCl_4$
аурат натрия $NaAuO_2$
сернокислая тетраммино-медь $[Cu(NH_3)_4]SO_4$
хлористая дихлоро-тетраммино-платина (4) $[Pt(NH_3)_4Cl_2]Cl_2$
хлористый диакво-тетраммино-кобальт (3) $[Co(NH_3)_4(H_2O)_2]Cl_3$

(*i*) *Miscellaneous Inorganic Compounds.* A number of important compounds await mention. Note the distinction between

[8]соляная кислота Hydrochloric acid
(Literally "salt acid"; *cf.*, German *Salzsäure*)
хлористый водород, хлороводород } HCl
[9]фтористоводородная кислота, фтороводородная кислота } Hydrofluoric acid
фтористый водород, фтороводород } HF
бромистоводородная кислота, бромоводородная кислота } Hydrobromic acid
бромистый водород, бромоводород } HBr
иодистоводородная кислота, иодоводородная кислота } Hydriodic acid
иодистый водород, иодоводород } HI

The Russian nomenclature for compounds related to cyanogen is based on the word, синерод, which literally means "blue former" (синий, blue). In forming names of compounds related to cyanogen, the term, синерод, is used in much the same way as the name of an element. Note the following:

синерод, циан } $(CN)_2$
хлористый синерод ClCN
синеродистый натрий NaCN
синеродистое серебро AgCN
синеродистое железо $Fe(CN)_2$
синеродное железо $Fe(CN)_3$
синеродистый водород, дианистыи водород, синеродводород } HCN
синильная кислота, дианистоводородная кислота } Hydrocyanic acid
синеродистая кислота, циановая кислота } HCNO
синеродистонатриевая соль, циановонатриевая соль } NaCNO
железистосинеродистый калий $K_4Fe(CN)_6$
железносинеродистый калий $K_3Fe(CN)_6$

[8] Sometimes also termed хлористоволородная кислота or хлороводородная кислота.
[9] A commonly used name is плавиковая кислота.

The closely related thiocyanogen derivatives are named similarly.

родан $(CNS)_2$
(*Cf.* German *Rhodan*)
родановодород HCNS
роданистый натрий NaCNS
роданистое железо $Fe(CNS)_2$
родановое железо $Fe(CNS)_3$

The naming of ammonia and ammonium compounds should also be noted carefully.

аммиак NH_3, also, loosely, for aqueous ammonia
гидрат окиси аммония NH_4OH
аммоний NH_4
аммониевый ион NH_4^+
хлористый аммоний, хлористоводородный аммиак } NH_4Cl
азотистоаммониевая соль NH_4NO_2
азотноаммониевая соль NH_4NO_3
серноаммониевая соль $(NH_4)_2SO_4$

The adjective, аммиачный, is also used, particularly in referring either to ammonia-containing compositions or to devices for handling ammonia.

аммиачная вода ammonia water
аммиачный латекс ammoniated latex
аммачный компрессор ammonia compressor
аммиачный скруббер ammonia scrubber

The following nitrogen containing compounds are closely related to ammonia:

гидроксиламин NH_2OH
сульфат гидроксиламина, сернокислый гидроксиламин } $(NH_2OH)_2 \cdot H_2SO_4$
хлористоводородный гидроксиламин, солянокислый гидроксиламин } $NH_2OH \cdot HCl$
гидразин $(NH_2)_2$
гидрат гидразина $(NH_2)_2 \cdot H_2O$
азотистоволороднаякистола, азотоволороднаякислота } HN_3

Hydrates of metal oxides may be named in various ways, for example:

гидроокись, водная окись, гидрат окиси, гидрат } цинка $Zn(OH)_2$
гидрат закиси золота AuOH
гидрат окиси золота $Au(OH)_3$

The Russian names of acid salts may be formed (1) by using the adjective кислый, (2) by prefixes or adjectives derived from numerals, or (3) by names corresponding to the English "bisulfate of sodium" or the like.

кислый сернокислый натрий, бисульфат натрия } $NaHSO_4$
кислый углекислый натрий, двууглекислый натрий, бикарбонат натрия } $NaHCO_3$
фосфорноднонатриевая соль, первичный кислый фосфорнокислый натрий, первичный кислый ортофосфат натрия } NaH_2PO
фосфорнодвунатриевая соль, вторичный кислый фосфорнокислый натрий, вторичный кислый ортофосфат натрия } Na_2HPO_4
кислая фосфорнокальциевая соль $CaHPO_4$

In this connection, note that various numerical prefixes and the adjectives средний and нормальный are

sometimes used to avoid possible ambiguity when speaking of neutral salts.

средняя[10] фосфорнокальциевая соль
нормальная фосфорнокальциевая соль } $Ca_3(PO_4)_2$
фосфорнотрехнатриевая соль
нормальная фосфорнонатриевая соль } Na_3PO_4

The adjective, основной,[11] may be used in naming basic salts.

основная фосфорно-железная соль
basic ferric phosphate
основная углесвинцовистая соль
basic lead carbonate
основная азотная соль окиси ртути
basic mercuric nitrate

Note the use of уранил (uranyl); антимонил, стибил (antimonyl); висмутил (bismuthyl), etc., in naming certain salts.

азотностибиловая соль $(SbO)NO_3$
бромистый висмутил $(BiO)Br$
сернокисливый антимонил $(SbO)_2SO_4$
ацетат уранила $UO_2(C_2H_3O_2)_2$

The adjective, двойной (double, binary), may be used in referring to double salts.

двойная серножелезистоаммониевая соль
$FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$
двойная соль уксуснокислого[12] уранила и уксуснокислого натрия $UO_2(C_2H_3O_2)_2 \cdot 2NaC_2H_3O_2$

The following names of thio acids and their salts illustrate the willingness of Russians to combine Russian and foreign roots in the same word.

тиомышьяковистая кислота H_3AsS_3
тиомышьяковая кислота H_3AsS_4
дитиофосфорная кислота $H_3PO_2S_2$
тритиоугольная кислота H_2CS_3
пертиоугольная кислота
надтиоугольная кислота } H_2CS_4
тиосурьмянистокислый натрий
сульфосурьмянистокислый натрий } Na_3SbS_3
тиооловяннокислый натрий
сульфооловяннокислый натрий } Na_3SnS_4

The names of the following compounds are closely related to the names of component elements and radicals.

хлорокись фосфора $POCl_3$
хлорокись хрома CrO_2Cl_2
амид натрия $NaNH_2$
хлористый сульфурил SO_2Cl_2
хлористый тионил $SOCl_2$
пятикарбонил железа $Fe(CO)_5$
хлористый нитрозил $NOCl$

SUPPLEMENTARY NOTES

(*a*) *A Point Requiring Special Attention.* In translating chemical Russian special attention must be given to adjectives derived from nouns denoting electronegative elements. Such adjectives require different translations depending on the nouns which they modify.

For example, the adjective, хлорный, cannot be translated by any single English word. This is true of other, similarly derived adjectives, as is illustrated by the following examples:

хлористая медь $CuCl$
хлорная медь $CuCl_2$
хлористое железо $FeCl_2$
хлорное железо $FeCl_3$
сернистая медь Cu_2S
серная медь CuS
хлористая кислота $HClO_2$
хлорная кислота $HClO_4$
хлористое серебро $AgCl$
хлористый алюминий $AlCl_3$
сернистая кислота H_2SO_3
серная кислота H_2SO_4

These examples also illustrate the fact that certain adjectives with suffix -ист-, *e. g.*, хлористый, may be used (1) to name a salt containing a metal, *e. g.*, Cu, in a lower valence state, as in CuCl, or (2) to name salts of metals existing in only one valence state, *e. g.*, Al. However, adjectives formed with the -ист- suffix may be used sometimes in naming a salt containing a metal in its *higher* valence state, provided the higher valence state is thought of as being the more common or usual valence state of the metal when functioning as a cation in salts. A similar irregularity in usage occurs when окись is used, *without further qualification*, in naming the lower member of a pair of salt-forming, metal oxides. The following examples are typical:

иодистая ртуть HgI_2 хлористая медь $CuCl_2$
сернистая[13] ртуть HgS хлористое олово $SnCl_4$
окись олова SnO

Since loose usage of this sort sometimes occurs, some Russian authors prefer to use numerals, or prefixes derived from numerals, to avoid all chance of ambiguity. Thus, CuCl may be termed однохлористая медь, or полухлористая медь, $SnCl_4$ четыреххлористое олово (одно-, mono-; полу-, semi-; четырех- tetra-), while SnO may be designated окись олова (2).

(*b*) *Proposals for Reforming the Russian Inorganic Chemical Nomenclature.* Russian chemists are not entirely satisfied with the methods used in Russian to name inorganic compounds. Various proposals (*1*, *2*) have been made for reforming Russian inorganic chemical nomenclature so as to eliminate possibilities of misunderstanding and ambiguity. These proposals will not be reviewed in this paper.

(*c*) *Russian Trivial Names for Some Important Inorganic Compounds.* The following list of Russian trivial names of inorganic compounds is intended to be helpful rather than complete. Very few Russian names of minerals are given, as transliteration usually suffices to render such names easily recognizable. Russian trivial names for a few important organic compounds are also included.

[10] The feminine, nominative singular ending of certain Russian adjectives is -яя.
[11] The masculine, nominative singular of certain Russian adjectives ends in -ой.
[12] The adjective, уксуснокислый, is derived from уксусная кислота, *acetic acid*.
[13] The instability of Hg_2S offers some logical basis for the use of сернистая ртуть for HgS.

алабастр	alabaster
английская соль	*cf.*, эпсомская соль
белый купорос	white vitriol, $ZnSO_4 \cdot 7H_2O$
белый мышьяк	white arsenic, As_2O_3
берлинская лазурь	Prussian blue
бертолетова соль	Berthelot's salt, $KClO_3$
благородный газ	noble gas, *i. e.*, He group gas
благородный металл	noble metal
болотный газ	marsh gas, CH_4
бура	borax
водная известь	hydrated lime, $Ca(OH)_2$
гашеная известь	slaked lime, $Ca(OH)_2$
глауберовая соль	Glauber's salt, $Na_2SO_4 \cdot 10H_2O$
глинозем	alumina
горькая соль	*cf.*, эпсомская соль
горькозем	magnesia
гремучая ртуть гремучертутная соль	fulminate of mercury
гремучий газ	mixture of $2H_2$ and O_2
древесный спирт	wood alcohol, CH_3OH
древесный уголь	charcoal
едкая известь	$Ca(OH)_2$
едкий аммиак	NH_4OH
едкий барит	$Ba(OH)_2$
едкий литин	LiOH
едкий натр едкий натрий	NaOH
едкое кали	KOH
жавелевая вода	Javel's water, aqueous hypochlorite solution
железный купорос	iron vitriol, $FeSO_4 \cdot 7H_2O$
желтая кровяная соль	$K_4Fe(CN)_6$
змеевик	serpentine (mineral)
известковая вода	lime water
известковое молоко	milk of lime
известняк	limestone
известь	lime
кали	K_2O
каменная соль	rock salt
квасцы	alum
кинобарь	cinnabar
красная кровяная соль	$K_3Fe(CN)_6$
кремнезем	silica
крепкая вода	concentrated HNO_3
маслородный газ	C_2H_4
массикот	litharge
натр	Na_2O
нашатырный спирт	aqueous ammonia
нашатырь	NH_4Cl
негашеная известь	unslaked lime, CaO
оловянная соль	tin salt, $SnCl_2 \cdot 2H_2O$
оловянный камень	tin stone, SnO_2
плавиковая кислота	hydrofluoric acid
поваренная соль	cooking salt, NaCl
прусская кислота	prussic acid, aqueous HCN
прусская лазурь	Prussian blue
рвотый камень	tartar emetic
редкоземельный металл	rare earth metal
родан	thiocyanogen
свинцовый сахар	sugar of lead, $Pb(C_2H_3O_2)_2$
селитра	saltpetre
селитряная кислота	HNO_3 (*cf.* German *Salpetersäure*)
синий купорос	blue vitriol, $CuSO_4 \cdot 7H_2O$
синильная кислота	aqueous HCN
соляная кислота	hydrochloric acid
сулема	$HgCl_2$
сурик	Pb_3O_4
тяжелый шпат	heavy spar, $BaSO_4$
хамелеон	$KMnO_4$
хромовые квасцы	chrome alum
царская водка	aqua regia
чилийская селитра	Chile saltpetre, $NaNO_3$
щелочный металл	alkali metal
щелочноземельный металл	alkaline earth metal
эпсомская соль	Epsom salt, $MgSO_4 \cdot 7H_2O$

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EDITOR'S OUTLOOK (*Continued from page 105*)

If an intellectually mature person (more or less!) is to spend one semester, say, in the study of chemistry, what impressions should we try to leave in his mind? Should he come away with an appreciation of the fact that chemists have contributed to the richness of our present civilization by making life easier, more attractive, and more abundant? Certainly it is a thought worth leaving. Should he be able feebly to *practice* the art of the chemist, at least to the extent of titrating an acid with an alkali, writing the symbolic "equation" for the process, and carrying out the arithmetical calculations which it implies? Perhaps not a very useful accomplishment, but maybe of *some* value, although it scarcely tends to give the chemical profession much dignity. Or should he have at least a glimmering of understanding of the "fine structure" of nature, which determines the ultimate, visible behavior of matter? Such use of imagination might lead him to see the ever-changing world about us as the chemist sees it.

It is a question of relative values. But in making a choice of content we must keep in mind the purposes of liberal education, which will be different from those of technical or professional training. It is not a new problem, this fixing upon objectives. But we shall now be required to consider it more seriously than heretofore. It will be interesting to survey the results.

Russian in the Chemist's Curriculum[1]

J. G. TOLPIN

Universal Oil Products Company and Northwestern University, Chicago, Illinois

THERE is a store of chemical information, ranking high in importance and reliability, contained in the current, and, to some extent, in the older Russian scientific literature. The editor of *Chemical Abstracts* states that it is "reasonable to predict that Russia has permanently replaced Germany as the strongest European scientific contributor" (*6*). Already in 1940 every seventh chemical paper in the world was published in Russia (*5*). Russian chemists claim a higher percentage, at least for some branches of chemistry. For instance, of the papers on inorganic and physical chemistry published throughout the world, the Russian papers were stated (*17*) to amount to 8.2 per cent in 1930, 17.3 per cent in 1940, and 20.6 per cent in 1941 (the last figure refers to the first 23 weeks of the year, before the war spread to the U.S.S.R.).

It should be stressed that figures similar to those for the development of chemistry may be quoted for other fields of research. For instance, a search of the references to technical articles given in the journal, *Wireless Engineer*, in 1940 revealed that for each 100 German references there were 57 Russian references (*15*). In some of the biological sciences the U.S.S.R. may soon lead the world, in the judgment of some authorities (*10*). Similar opinions have been expressed with reference to applied mathematics and mechanics (*11*). The necessity to follow Russian publications in these fields is obvious.

This information is insufficiently known, in part, even entirely overlooked by the English-speaking chemist, although some outstanding members of our profession have on various occasions urged that chemists study the Russian language. Among representatives of other branches of science, a number of American and British chemists recently participated in the festivities marking the 220th anniversary of the Russian Academy of Sciences, and upon their return from the Soviet Union they were said to be unanimous in the opinion that the development of science goes forward there on a great and partly unsuspected scale and that we fail to provide our younger scientists with the advantage of closely studying this development through reading the Russian scientific publications, whereas the knowledge of English is very widespread among Russian scientists (*9*). The necessity for chemists to study Russian was also indicated in 1924 in an address by Professor W. P. Wynne, president of the London Chemical Society (*16*). The number of those who followed his advice is small. American chemists who in the past studied Russian for the value of the Russian chemical literature are exceptions to the general rule. About twenty-five years ago, a research student at Yale interrupted his academic work for a year in order to gain proficiency in the Russian language sufficient to read the original researches of Professor V. N. Ipatieff. Today this man, Professor F. A. Gilfillan, is Dean of the School of Science, Oregon State College, and is teaching scientific Russian to his students of chemistry.

I am of the opinion that at this moment it becomes the responsibility of the chemical profession to provide means for and to facilitate actively the obtaining of information about Russian chemical research—as complete information as is being published in Russia. The interest of the American chemical industries has been aroused—of that I have definite indications. The cooperation of the Russian scientists and publishing organizations can be obtained if an organization as authoritative as the American Chemical Society will take the initiative. I propose to discuss in this paper means for possibly fuller utilization of this information.

It may be worth while to examine the causes of the amazing lack of information on scientific researches in Russia existing in this country. It is due to a combination of factors, such as the pronounced difference in language and geographical factors, in addition to political differences. It is not due to any unusual secretiveness of the Russian scientists in the past or now. A large proportion of Russian scientific reports appeared in German and French and, to some extent, in English throughout the past 220 years since the Russian Academy of Sciences was founded. Other Russian scientific organizations also have sought to present their activities to the colleagues abroad. For instance, in 1893 at the occasion of the World's Columbian Exposition in Chicago, a short historical sketch of the Imperial Russian Technical Society was published in this city, describing its activities since its inception in 1866.

In recent years, when by far the greatest amount of its research reports are published in Russian, the Soviet Academy of Sciences publishes for the benefit of the non-Russian scientists several journals in non-Russian languages, lately almost exclusively in English, and also appends the Russian articles in many journals with English summaries. On special occasions, such as the recent celebration of the 220th anniversary of the Russian Academy of Sciences, extensive reviews appear in the Russian scientific journals covering various fields of science.

Historically speaking, one of the obstacles in the way of better acquaintance of English-speaking scientists with details of Russian research may have consisted of the influence of Germans in Russian research. Among the scientists invited at the inception of the Russian Academy of Sciences to work in that institu-

[1] Presented before the Division of Chemical Education, Chicago section of the American Chemical Society, at the fiftieth anniversary one-day technical conference, November 16, 1945.

tion, the number of Germans was large. The contributions to science made by some Russian scientists of German extraction have been great in many fields, but credit for them was sometimes given to Germany, especially because Russian scientists, regardless of their origin, always contributed to German scientific publications. Thus, not only were Russian chemists with German names—G. H. Hess, the founder of thermochemistry; the organic chemists, F. F. Beilstein and E. E. Wagner; the colloidal chemist, P. P. von Weimarn, and many others—considered by some to be Germans, but many chemists with definitely Russian names, as well, and their researches were thought to be limited to what they published in the German language. Some Germans in Russia had a hindering effect and looked with mistrust at some outstanding works of Russian scientists. It is known that both Lomonosov and Mendeleev were hampered in their work by these German officials in Russian science, and Mendeleev could not be elected to full membership in the Academy of Sciences because of the opposition of the then-president of the Academy of Sciences, Th. P. Litke.

It is also true that up to recent time Russian science was cloistered in laboratories and did not have much influence upon industry in Russia. Russian researches were relatively well known in Germany, where they were in some cases made commercial use of. Some raw materials used to be exported from Russia to Germany and shipped back in the form of finished products because there was no Russian industry to process them. In a recent article one of the leaders of chemical research in the U.S.S.R. states that the tie between laboratory research and industry is still insufficient in the U.S.S.R. even today, though great efforts are consistently being made to achieve this (*12*). N. N. Zinin's synthesis of aniline in 1842, M. Kucherov's hydration of acetylene to acetaldehyde in 1881, A. E. Favorskiĭ's earlier studies of derivatives of acetylene, which began about 60 years ago, research on catalytic phenomena and high pressure reactions by Prof. V. N. Ipatieff before his coming to this country, numerous conversions of petroleum hydrocarbons, and investigation of the constitution of petroleum by A. M. Butlerov, V. V. Markovnikov, N. D. Zelinskiĭ, and their coworkers are only a few examples of researches that deserved detailed study at the time of their publication.

Today the situation is quite different. The development of pure, as well as applied, science in the U.S.S.R., in connection with the industrialization of the country, which equipped it for the greatest war in history, has reached proportions which compel a close acquaintance with it. It deserves reiteration that the development of Russian science is not simply a taking over of non-Russian practices. This is inconceivable in a country with peculiarities of economic structure and natural resources as those characterizing Russia of the past or today. Foreign processes have to be studied and adapted to Russian conditions, and in the course of that adaptation new data are being accumulated of general interest and importance. Moreover, the greatest part of researches being reported in the Russian scientific journals deals with problems peculiar to Russian economic conditions and is done under the influence of schools of science—in the case under discussion, chemistry—that have, in many cases, 100 years' standing. Admittedly the manner in which these researches are written differs from ours (*13*), but this does not in itself constitute an argument against the data presented.

The Russian researches on oil refining from the time of Mendeleev on were inspired by the potentialities offered by the riches of oil in Russia; the researches on platinum metals of L. A. Chugaev, O. E. Zvyagintsev, and others (*8*) are similarly due to deposits of these metals in the Ural mountains.

In 1915 the Russian Academy of Sciences created a committee for the study of natural resources, headed by V. I. Vernadskiĭ, which was later continued in various forms. A successor to this committee is acting now in the U.S.S.R. under the chairmanship of V. L. Komarov, who recently relinquished the presidency of the Academy of Sciences, and has surveyed the flora and fauna of the country and during the war discovered numerous resources of vital importance to the war effort. It requires no special elaboration to prove that the utilization of these resources will result in the development of original methods of study.

Many years ago A. A. Voskresenskiĭ started in Russia a line of research on isolation of alkaloids from natural sources. This work, continued by A. A. Chichibabin and A. P. Orekhov and his coworkers, resulted in the isolation of a large number of alkaloids, many of which, such as anabasine, have a high commercial value, and also in the synthesis of a series of new alkaloids. Thus, this work, which began as a purely Russian project, cannot be ignored by anyone interested in the field of alkaloids.

Just as important, however, is the parallelism of scientific interest in other fields of chemistry. The peculiar conditions prevailing in Russia made it necessary for the Russian chemists to study synthesis of rubber many years before we were faced with an acute need for these data. They began operating the first plant for the manufacture of synthetic rubber from ethanol by the S. V. Lebedev method in 1931. The interest which we had in their data in these fields in 1941 and 1942 is well known to every American chemist. These Russian developments were followed by researches on all other methods of synthesizing rubber, including polymerization of isoprene and chloroprene and copolymerization of various components, as well as cultivation of native rubber-bearing plants.

In 1943 the U. S. Government appropriated $30,000,000 for experimentation, under the supervision of the Bureau of Mines, on the synthesis of liquid fuel from sources such as shale, coal, etc. Russian geography made it necessary to study conversion of peat, shale, and coal in the early 1930's, and information which

reached me only very recently shows that in 1939 the Soviet Institute of Mineral Fuels had constructed and had partly in operation a full-scale commercial plant for shale conversion in the Leningrad province, and had made a successful 1000-km. automobile test run on shale gasoline. This plant was apparently later ruined by the Germans and was being rebuilt in 1944.

The researches of Peter L. Kapitsa on liquefying gases make oxygen available at prices low enough to consider its use in industries such as underground gasification of coal, metallurgy, and so on.

It is not intended here to enumerate all Russian chemical researches of importance. Those interested should be referred to the Russian technical literature. There were in 1941 more than 50,000 chemists in the U.S.S.R. (*1*), and chemical research was being carried out in over forty institutes (*2*). The amassed data of these research institutes are being published in the Russian technical literature. There were at least 300 technical publications in the U.S.S.R. in 1939; this refers to those published in the Russian language only. This number decreased substantially during the war.

The interest of the individual scientist in researches of importance is stimulated by various means. A number of prizes have been instituted for important researches. They include the older awards, such as those given by the Mendeleev Chemical Society, the Stalin prizes ranging from 25,000 to 100,000 rubles, Lebedev prizes for outstanding studies on synthetic rubber, etc. However, the prestige of the Russian research worker gained by publication of scientific articles is singularly important in his career, and therefore his personal desire is to publish his data.

Let us hope that termination of the war will also free much of the data previously withheld from publication. Of the existence of these data there are definite indications. Recent issues of Russian technical periodicals have carried news of plans and decisions to expand the chemical literature, to restore some journals the publication of which was interrupted by the war, to improve research facilities, and to concentrate on restoration, improvement, and expansion of various industries (*14*).

It is generally understood that the U.S.S.R. may become a very large factor in the postwar foreign trade of this country. If we are to supply them in the chemical field with goods and services, we obviously must know the state of their chemical industry.

Evidently, detailed knowledge of the Russian progress in chemistry cannot come from abstracts, the purpose of which is only to call attention to the articles covered, and especially considering that much Russian literature never reaches us. This is true for summarized information appearing in the form of books, provincial publications, reports of various experimental plants, and so on. As a result, Russian scientists occasionally complain of the lack of recognition given to their developments outside of Russia (*7*).

In order to provide detailed information on the Russian scientific researches, special facilities are needed. These facilities may comprise special instruction in Russian for chemists, training of chemical translators from Russian, and a system of exchange students.

A large number of American universities have introduced Russian as a subject of instruction (*4*). Whereas before the war only a few universities offered Russian, in the school year 1944–45 this number rose to 81. Few of these courses are specially designed to meet the interests of the scientist aiming at being able to read the literature in his field. A recent preliminary survey[2] shows, however, that in a large percentage of cases scientists are studying Russian in mixed classes in which colloquial Russian is the primary objective. A number of these classes are offered in the evening schools. At the present time chemists apparently study Russian in larger numbers than do workers in other branches of science; frequently the employer pays the tuition fees. Some of our major chemical companies now have classes in Russian on their premises. Undoubtedly, interest on the part of the American Chemical Society in this subject will lead to an increase of the number of special classes offered for chemists, and, what is important, inclusion of Russian in the program of the daytime student in chemistry.

Substantial help in introducing this measure may come from recognition of Russian on a par with German and French as a part of the language requirements for a Ph.D. degree in chemistry. According to my information, at least 20 American universities have already established precedents or taken official decisions in that sense, and in some schools Russian is even recommended to graduate students in science and mathematics.

There are not enough qualified translators of chemical Russian. A bibliographical worker is usually called upon to handle a field wider than that in which an individual research worker has interest, and for this reason a different program of study is necessary for the training of a writer or bibliographer covering the Russian technical literature. I believe that this training may best be given in the form of one or two semesters of concentrated full-time study on a graduate-school level through scholarships from interested industries. The qualifications of a candidate for this academic work will have to include some preliminary study of Russian.

In the future a course may also be designed under the auspices of a library school for the purpose of acquainting librarians with the Russian scientific literature.

The advantages of exchanging students with other countries need not be discussed here. Considerations which have nothing to do with science may be an obstacle in the way of organizing such a system of exchange students with the U.S.S.R. for the time being; however, we are concerned with the scientific aspect only. It deserves note that the Academy of Sciences of the U.S.S.R. includes exchange of scientific workers between the U.S.S.R. and foreign countries as one of

[2] This survey is conducted by a committee of the American Association of Teachers of Slavonic and East European Languages.

their most important means of promoting international cooperation in science (*3*). For a scientist going to the U.S.S.R. a period of special training in the language on the above-mentioned lines, however, on a narrower scope to suit his needs, should be designed, and it is not premature to give some thought to this subject now.

A pressing need exists to create stores not only of current, but also older, Russian technical publications. The poverty of our libraries as far as Russian technical material is concerned has been indicated a number of times. Various organizations in this country are now taking steps to offset this disadvantage. I don't expect much success, unless an organization carrying the prestige of the American Chemical Society or the Library of Congress should officially start an action for this purpose, for it must be remembered that the Russian publication facilities are hard pressed, and technical publications there are always printed in numbers of copies considerably smaller than the demand. Books are in most cases sold out before orders from this country arrive. I am confident, however, that we could secure, either on an exchange basis or through microfilming, all the publications needed, if a suitable arrangement could be made, for instance with the Mendeleev Chemical Society. The Russian scientific publications so acquired should be deposited in a library or libraries, through which they should be made available to the chemical profession and industry on a loan basis or in the form of photostats. A detailed list of the present holdings of Russian scientific material in this country is also needed, to which supplements could be published in the future.

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Conversion Factors in Physical Chemistry

PAUL PORTER SUTTON

North Carolina State College, Raleigh, North Carolina

IN PHYSICAL chemistry, even at the elementary level, it is often necessary to treat special instances of the following general problem: A given quantity has magnitude a when measured in the system of Units I; what would be its magnitude x when referred to II, another system of units? This type of problem can be disposed of by the discovery of a conversion factor k so that

$$x = ka \qquad (1)$$

said factor being dependent on the systems I and II in such a way that

$$1 \text{ unit of I} = k \text{ units of II} \qquad (2)$$

Many of these factors are known to all who enter the study of physical chemistry but others are much less familiar, *e. g.*, 1 cal. = 41.03 cm.^{3} × atm., a relation frequently needed in problems centering around the exact Clapeyron equation. Despite their importance for numerical work, even in the field's most recent new text,[1] such relations are simply presented to the student as needed without any attempt to tie them up with previously acquired data. It seems well, therefore, to emphasize that the conversion factors most commonly called for can all be evaluated by comparison of correctly chosen values of the molar gas constant. The following compilation makes this point clear:

1.987 cal./mol. × deg. = 82.06 cm.^{3} × atm./mol. × deg.
- 1 cal. = 82.06/1.987 = 4.103 × 10^1 cm.^{3} × atm.
- 1 cm.^{3} × atm. = 1.987/82.06 = 2.413 × 10^{-1} cal.

1.987 cal./mol. × deg. = 8.315 joules/mol. × deg.
- 1 cal. = 8.315/1.987 = 4.185 joules
- 1 joule = 1.987/8.315 = 2.389 × 10^{-1} cal.

82.06 cm.^{3} × atm./mol. × deg. = 8.315 × 10^7 $\frac{\text{dynes}}{\text{cm.}^2}$ × cm.^{3}/mol. × deg.
- 1 atm. = 8.315 × 10^7/82.06 = 1.013 × 10^6 dynes/cm.^{2}
- 1 dyne/cm.^{2} = 82.06/8.315 × 10^7 = 9.868 × 10^{-7} atm.

The author's experience has shown that the average student can readily master the method illustrated in the above table and that by its application to specific problems there is acquired an increased appreciation of dimensional reasoning as well as greater proficiency in computations.

[1] PRUTTON, C. F., AND S. H. MARON, "Fundamental Principles of Physical Chemistry," The Macmillan Company, New York, 1944.

A Simple Laboratory Hot-Air Dryer

I. R. C. BICK

University of Queensland, Brisbane, Australia

A MEANS of drying rapidly glassware and other apparatus is a virtual necessity in the chemical laboratory, particularly for organic work. An apparatus for this purpose has been described by Dunbar in THIS JOURNAL [**20,** 130 (1943)], which consists essentially of a gas-heated copper tube wound into the form of a helix through which a current of air is passed. This form of apparatus, while being extremely convenient, has certain disadvantages; in particular, after using it for some time, the tube becomes coated internally with a loose scale of copper oxide which is readily detached and carried over into the vessel that is being dried. In addition, the use of a gas flame involves the risk of a "flash-back," or minor explosion, if the vessel has been rinsed with alcohol or some other inflammable organic solvent to assist the drying.

It is believed that the apparatus herein described possesses advantages in being simple, robust, and easily and cheaply constructed from materials at hand in any laboratory; in addition, it is free from the disadvantages mentioned above.

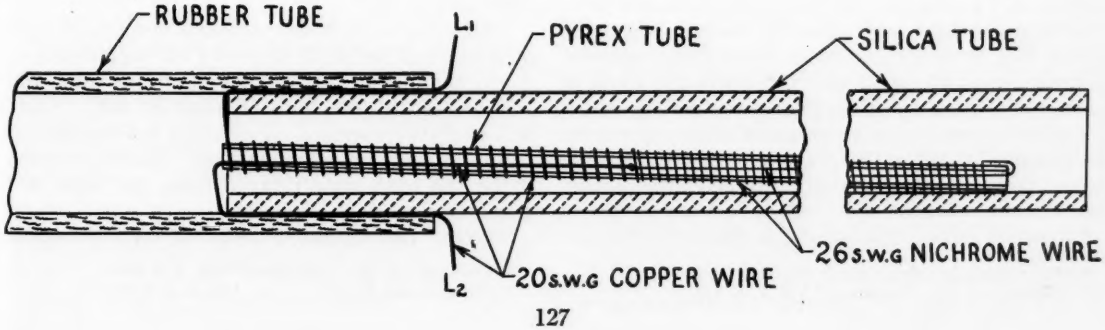
An electrically heated element is used which consists of about 350 cm. of 26 S.W.G. nichrome wire wound loosely around a pyrex tube 45 cm. in length and having a 2-mm. bore, leaving about 5 cm. free of wire at one end. Connections are made at each end with 20 S.W.G. copper wire; at the end left free of nichrome wire, the winding is continued with copper wire to the end of the tube. The copper wire at the other end is threaded through the tube, and the nichrome wire is drawn through almost the whole length of the tube until the connection with the copper wire is within 5 cm. of the end. The heating element so formed is placed inside a silica tube about 46 cm. long, of 15 mm. external diameter and 10 mm. bore. The silica tube used in this laboratory was taken from a broken thermocouple; if desired, a pyrex tube could be substituted. The electrical connections, which are taken out from the same end, but at diametrically opposite positions, serve to keep the heating element in place. A wide-bore rubber tube is slipped over the end of the silica tube and the connecting wires to a distance of about 3 cm., as the latter are held firmly in position and are insulated from one another; at the same time an airtight seal is formed, particularly when a clamp is placed over the rubber tubing and connecting wires. The rubber is connected to a foot-bellows or some other supply of forced air.

The silica tube is mounted to a retort stand over that part of it which is covered by the rubber tubing. It was found most convenient to incline it at an angle of about 30° to the horizontal with the lower end about 8 cm. above bench level. The element, with a pilot lamp in parallel, is connected to a 240-v. main supply through a switch mounted on the base of the stand.

In using the dryer it is found unnecessary to keep the heater on continuously, since an instantaneous supply of hot air is available whenever it is switched on. The apparatus to be dried, which has been rinsed with alcohol, is held at an angle above the end of the tube; this permits draining of the excess alcohol and promotes rapid drying.

In cases where it is desired to dry apparatus with a narrow opening, an adapter is slipped over the end of the silica tube. This consists of a pyrex test tube just wide enough to fit easily over the silica tube, with a narrow-bore pyrex tube sealed into the bottom.

A dryer of this type has been in constant use by students in our laboratories for over a year and has proved itself to be thoroughly foolproof and reliable despite its simple construction. Since the hot element is always surrounded by an upward stream of air, the possibility of a "flash-back" is negligible even when ether is used to assist the drying.



Chemical Knowledge in the New Testament

HUGO ZAHND and DOROTHY GILLIS

Brooklyn College, Brooklyn, New York

(*Continued from page 97*)

The fact that the ancient Israelites were familiar with wine and its intoxicating property is clear from the following quotation: "And Noah began to be an husbandman, and he planted a vineyard: And he drank of the wine, and was drunken; and he was uncovered within his tent." The wines known to the early Hebrews were prepared by the fermentation of the juice from the grape or the pomegranate. In later times other intoxicating drinks were fermented from other fruits and from a number of vegetables. The medicinal value of wine was also appreciated at an early date. It was an ancient custom to give medicated or drugged wine to the condemned prisoners in order to mitigate the pain of execution. In the Talmud we find reference to the custom of adding a grain of frankincense to a cup of wine.[88] The Latin word, "poscae," refers to a cheap acid wine diluted with water which served as a common drink for the Roman soldier.[89] The mixed wine of the Hebrews differed from that of the Greeks and Romans. It was wine containing potent ingredients and was preserved in bottles of leather or goat skin.[90] The skins were used with the rough side inward.

Several references to wine, metaphorically or otherwise, are found in the New Testament (**Luke** 22:18; 23:46; **Revelation** 14: 10; **Matthew** 27:48; **James** 19:29; **Mark** 15:23). New wine (an intoxicating beverage made from pure grape juice), sour wine (vinegar), the fruit of vine, and the unmixed wine of the wrath of God are the translations for the different expressions found in the Classical Greek language for the term of wine.

Mark gives us a clue to the method of preparation of wine in the following words: "A certain man planted a vineyard and set an hedge about it, and digged a place for the winefat and built a tower" (**Mark** 12: 1). The wine press is pictured as consisting of three basins, placed one above the other, and all excavated in solid rock. While the grapes were trodden and pressed in the uppermost basin, the juice thus formed poured into a narrow channel, whence it flowed to a basin further down where it was allowed to settle until drawn off into the third and smallest basin.[91] In the book of **Revelation** we find the wrath of God compared to the great power of the wine press (**Revelation** 14: 19). The practice of preserving wine in goat skins, and the fact that continued fermentation of the wine caused old skins to rupture, elucidates Matthew's statement that "Neither do men put new wine into old wine-skins" (**Matthew** 9: 17).[92]

As vinegar was not used as a drink, the "vinegar and gall" offered to Christ on the cross (**Matthew** 27: 34) is therefore more correctly interpreted as "wine and myrrh" (**Mark** 15: 23).

The burning of incense (derived from the Latin "to burn") was practiced during the religious ceremonies of many of the ancient nations. It appears to be symbolical of the acceptance of the prayer rather than of the prayer itself. Incense refers either to a mixture of spices or gums producing a perfume when burned or to the perfume found in the substance undergoing combustion. Evidence available indicates that the incense burned during religious services in the Tabernacle was composed of the perfumes frankincense, galbanum, onycha, and stacte. The use of other ingredients was strictly forbidden. Additional perfume producing ingredients, used for incense and burned in the Herodian temple, were myrrh, cassia, spikenard, saffron, mace, cinnamon, and costus. The burning of the incense was carried out in a censer fashioned of gold or brass, the latter being a small portable vessel constructed to hold the burning coal by means of which the perfume was volatilized. Since the incense was burned at a fixed moment of each day, this rite served to mark the time of the day (**Luke** 1: 10). The sight of smoke rising toward heaven became associated with prayer (**Revelation** 8: 3).[93]

Frankincense is a fragrant, brittle, and glittering gum. The ancient Egyptians and the Jews of Biblical times used it frequently for sacrificial purposes. This bitter tasting gum resin, obtained from certain East Indian trees, was valued for its sweet odor when burned, and it was often recommended as a medicinal agent. Frankincense was brought to the Holy Land by Arabian merchants and it is mentioned as one of the gifts offered by the wise men to the infant Jesus (**Matthew** 2: 11).

Galbanum is a heavy-smelling resin and is first mentioned in the Bible as one of the ingredients used by Moses in order to compound the perfume which was ordered by the Lord (**Exodus** 30 : 34). Onycha was probably obtained by grinding the roasted operculum of some univalve shellfish. Stacte is assumed to be the solid resin derived from the bark of the storax tree.

Myrrh, the aromatic resin of Balsamodendron

[88] WHEELER, *op. cit.*, "The Gospels," p. 191.
[89] *Ibid.*, p. 194.
[90] M'CLINTOCK AND STRONG, *op. cit.*, Vol. 10, pp. 1014–6.
[91] VINCENT, *op. cit.*, "Matthew," Vol. 1, p. 117.
[92] VINCENT, *op. cit.*, "Matthew," Vol. 1, p. 55.
[93] CHEYNE AND BLACK, *op. cit.*, Vol. 2, p. 2165.

myrrha, was used for embalming (**John** 19 : 39–40) and for the manufacture of oil used for anointing. It also is numbered among the gifts from the wise men to the infant Saviour. The practice of its addition to wine has already been mentioned.

Cassia is probably identical with the *Cinnamonum Cassia* found in India. It is mentioned among the merchandise of Babylon (**Revelation** 18: 13). It is apparently the inner bark of the stem and twigs of the Cinnamonum Cassia which yield this spice.

Spikenard, derived from the roots of a perennial herb, is an odoriferous oil and was renowned for its medicinal properties. It was used either as an oily liquid or in the form of an ointment. Spikenard was considered as a most precious article (**Mark** 14 : 3; **John** 12: 3).

The stigma of the flower of the crocus, when dried and pressed, is known as saffron. It is mainly used for the seasoning of food. Mace is a product of the muscat nut and costus refers to the costly perfume derived from the roots of some species of costus. Cinnamon, the inner bark of *Cinnamomum Zeylanicum*, was used for the preparation of ointment and in conjunction with other odoriferous substances for the sprinkling of bed tapestry.

BLEACHING AND DYEING

The ancients were acquainted with two processes[94] required for the preparation of woven woolen materials. One deals with the cleansing or bleaching of the materials (**Mark** 9: 3), while the other involves the milling or felting of the wool so as to reduce shrinkage in the finished article.[95] The fullers employed in the task of bleaching the woolen garments lived on a special bleaching ground.[96]

The colors mentioned in the New Testament are white, scarlet, and purple. Thus we find reference to a white horse, a white cloud, a white throne, the white raiment of Christ at the transfiguration, the white raiment of angels, the white raiment of the redeemed, white hair, white fields, a white stone, a scarlet robe, and a purple robe (**Revelation** 6: 2; 19: 11; 14: 14; 20: 11; **Mark** 9: 3; **Luke** 9: 29; **Matthew** 28: 3; **Mark** 16 : 5; **Revelation** 3: 5; 4: 4; 7: 9; 19: 8, 14; **Matthew** 5: 36; **John** 4: 35; **Revelation** 2 : 17; **Matthew** 27 : 28; **Mark** 15 : 17).

Sepulchres (**Matthew** 23: 27) and walls (**Acts** 23: 3) were whitened. "Whited sepulchres" were graves covered with plastered structures which were ordered to be whitewashed the month before Passover in order to make them more conspicuous. It was further customary to whitewash each spring the stones guarding the entrance to the underground tombs of the Israelites.[97] Evidence available indicates that the whitewashing process was carried out by means of powdered lime.[98]

Dyes have been used by man for the longest time. Some of the natural dyes, derived from plants and animals, were in use probably 4000 years ago. The substantive colors used in ancient Greece were purple (discovered some 1500 years before the Christian era)[99] and blue; the former color was obtained from the murex and buccium, while the latter had its origin in indigoferous plants.[100] Since dyed garments were imported from Phoenicia and were very costly, the ancient Jews used probably mostly white robes. Evidence exists, however, that dyeing was practiced during Biblical times in Palestine. Rams' skins, for instance, were probably dyed red with kermes. The ancient Israelites were not acquainted with indigo (*Indigofera tinctoria*) but used the biennial plant woad (*Isatis tinctoria*) as a source for a blue dye. The latter dye was obtained from the leaves of this plant at a very early date. Dioscorides and Pliny refer to its use for dyeing wool; Caesar claims that the Britons used it for the staining of their bodies. It is possible that the ancient Hebrews were also acquainted with dyes obtained from the madder, the saffron crocus, the safflower, and tumeric. It has been suggested by some authorities that dyes other than red were imported rather than manufactured. The Israelites became familiar with the use of mordants and therefore were able to fix dyes on certain textiles.

According to the Holy Scripture, the robe which was placed on the shoulders of Jesus was either scarlet or purple in color (**Matthew** 27: 28; **Mark** 15: 17). This inconsistency becomes understandable if it is realized that any variation of red was called purple.[101] While scarlet colored clothing was well known to the inhabitants of the Holy Land, garments dyed with this color were not common in the Orient.[102] The cochineal, a red insect, was the source of the scarlet dye. The insects were killed by scalding with boiling water and then dried in the sun.[103] The Greeks and Romans, even before the time of Pliny, knew how to extract the scarlet dye from the insect kermes. It is also conceded that they were acquainted with the use of alum as a mordant.[104] Bancroft is of the opinion that Pliny assigned the name of alum to a sulfate of aluminum not identical with the alum of the present-day literature.[105]

The best known "dealer in purple" (**Acts** 16: 14) was Lydia of Thyatira and the tradesmen skilled in the art of dyeing in purple were known as the Lydians.[106] It appears most likely that Lydia used

[94] The modern terminology for both processes is "fulling" (from the Latin *fullare*).
[95] CHEYNE AND BLACK, *op. cit.*, Vol. 2, p. 1575.
[96] DELITZSCH, *op. cit.*, p. 40.
[97] CHEYNE AND BLACK, *op. cit.*, Vol. 4, p. 5138.
[98] VINCENT, *op. cit.*, "Matthew," Vol. 1, pp. 125–6.
[99] BANCROFT, E., "Experimental Researches Concerning the Philosophy of Permanent Colours," Dabson, Thomas, Philadelphia, **1814**, Vol. 1, p. 97.
[100] *Ibid.*, Vol. 1, p. xxxi.
[101] WHEELER, *op. cit.*, "The Gospels," p. 189.
[102] VINCENT, *op. cit.*, "Matthew," Vol. 1, p. 143.
[103] BANCROFT, *op. cit.*, Vol. 1, pp. 305, 317.
[104] *Ibid.*, Vol. 1, p. xviii.
[105] *Ibid.*, Vol. 1, p. xvii.
[106] WHEELER, *op. cit.*, "Acts of the Apostles," p. 68.

in addition to Tyrian purple (really crimson) other red dyes; cloth dyed with the famous Tyrian purple was far too expensive for the middle class.[107] The term "purple" originally referred to the purple fish from which the color was obtained. According to Vincent, the word "purple" was used for three different shades of color: deep violet tinged with black; crimson (the famous Tyrian purple); and the deep blue of the Mediterranean. The various shades of purple were produced by adding dyes of plant origin to the "purple" product.[108] The degree of permanency of the dye is indicated by Plutarch's claim that Alexander the Great found purple garments in the royal palace at Susa which had retained the original color tone over a period of nearly two hundred years.[109]

The purple dye (Tyrian purple) was obtained by crushing the bodies of certain specimens of shellfish (murex brandaris and murex trunculus). The expressed juice was diluted, treated with soda, and finally evaporated by heating the extract in tin or leaden vessels.[110] Some of the aspects of the chemistry of this dye are ably discussed by Bancroft and by Weeks.[111] The brief discussion by the latter author contains important references to the literature dealing with this subject matter.

Mineral substances were largely used for pigments contained in paints. At the time of Pliny these comprised white lead, vermillion, cinnabar, smalt, verdigris, red oxide of iron, and soot.[112]

TEXTILES

The Egyptians were acquainted with the art of weaving some 2500 years before the Christian era. They made fabrics of the finest quality from the cotton and linen which they had long since discovered. The inhabitants of ancient Greece made costumes from linen, cotton, or wool as early as the fifth century before Christ. While silk is mentioned by Aristotle, this material was not in general use until the beginning of the Christian era. The ancient Hebrews learned about linen from the Egyptians. They were acquainted with various grades of linen, the unbleached variety being used by the poor. Flax was grown at an early date in Palestine, and it was used in Canaan before the arrival of the Israelites. The flax fibers were blanched by exposing them to the sun and air. While cotton was cultivated in Egypt and in Persia at a very early date (probably antedating the earliest historical records), the Hebrews first became acquainted with it by way of contact with the Persians. Wool, however, was well known and constituted the principal textile for the manufacture of clothing. A mixture of linen and wool was not permissible in the fabrication of wearing apparel. Silk was in all probability unknown until the Roman period. Wool (**Revelation** 1:14), linen (**Revelation** 15:6, 19:8), and silk (**Revelation** 18:12) are the textiles mentioned in the New Testament.

CHEMICAL APPARATUS

In addition to various kinds of furnaces and ovens, the Israelites were familiar with various types of balances, mortars, pestles, and tongs. While the terms furnace, oven, and balance are found in the New Testament, no mention is made of the other implements.

Furnaces were commonly used for the process of smelting (**Revelation** 1:15; 9:2). The expression "furnace of fire" is used as a symbol of the intense heat that shall be applied in the punishment of the wicked (**Matthew** 13:42, 50).

Fixed and portable ovens were used by the Hebrews. The portable oven consisted of a large clay jar, several feet in height and wider at the bottom than at the top. It was heated by means of dry grass and twigs.[113, 114]

The Hebrews borrowed the art of weighing from the Egyptians. Both large and small balances of varied construction were in use. The accuracy of the balance and the weights were regarded as of divine importance; a "false balance" was considered an abomination.[115] Balances were most likely first used for the weighing of metals, money,[116] and grains, such as wheat and barley (**Revelation** 6:5, 6).

While no mention is made of mortars and pestles in the New Testament, it is well known that the earliest mode of preparing corn for bread was by crushing the grains in a hollow stone by means of another stone. Tongs were no doubt used for the handling of hot objects.

WATER, FIRE, AND RUST

The early Christians, not unlike other desert peoples, appreciated the value of water. Its usefulness for cleansing (**Luke** 7:44) and its thirst-quenching properties were held in high esteem (**Luke** 16:24).

Water was frequently used for religious ceremonials. Thus, the last day of the feast of Tabernacles was marked by the drawing of water from the fountain of Solomon and its subsequent pouring on the altar by a priest.[117] Jesus watching this ceremony cried, "If any man thirst let him come unto me and drink" (**John** 7:37). The use of water for the baptism of the believers has its origin with the birth of Christianity (**Matthew** 3:11; **Acts** 8:36; **Mark** 1:8; **Luke** 3:16; **John** 1:26, 3:23).

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[107] DELITZSCH, *op. cit.*, p. 9.
[108] BANCROFT, *op. cit.*, Vol. 1, p. 93.
[109] VINCENT, *op. cit.*, "Luke," Vol. 1, p. 396.
[110] WEEKS, *op. cit.*, p. 72.
[111] BANCROFT, *op. cit.*, Vol. 1, pp. 81–121; WEEKS, *op. cit.*, pp. 72–3.
[112] VON MEYER, E., "History of Chemistry from the Earliest Times to the Present Day," translated by M'GOWAN, Macmillan and Company, London, 1891, p. 18.
[113] VINCENT, *op. cit.*, "Luke," Vol. 1, p. 371.
[114] "The International Teachers' Handy Bible Encyclopedia and Concordance," Garden City Publishing Company, New York, 1940, p. 251.
[115] HASTINGS, *op. cit.*, Vol. 1, "Balance," p. 234.
[116] NAPIER, *op. cit.*, p. 32.
[117] WHEELER, *op. cit.*, "The Gospels," pp. 103–4.

The nonritualistic baptism of utensils and articles of furniture is alluded to in the New Testament (**Mark** 7:4, 8).[118]

From the theological point of view, baptism by means of water is a symbol for the consecration by the Holy Ghost (**Matthew** 3:11; **Mark** 1:8; **Luke** 3:16; **John** 1:33; **Acts** 1:5; 11:16; **I Corinthians** 12:13).

There are a considerable number of allusions to the figurative use of the term water. To cite but two examples:[119] by means of the statement "out of his belly shall flow rivers of living water" Jesus represents himself and every believer as a living temple which serves as a source of his wisdom, even as the fountain of Siloam serves as a reserve supply for water (**John** 7:38).[120] Jesus uses water also as a symbol for eternal life (**John** 3:5).

The Jews recognized the difference between sweet and salt water. Furthermore, they were also acquainted with the harmful effects of bitter water (**James** 3:11, 12; **Revelation** 8:11). According to Vincent, the bitter water mentioned in **James** refers to the bitter "waters of Marah" (**Exodus** 15:23) and to the unhealthy spring situated at Jericho (**II Kings** 2:19–21).[121]

The earth was believed to be "standing out of the water and in the water" and later was destroyed by a deluge of water (**II Peter** 3:5–6). The term "moisture," found in **Luke,** signifies the juices found in the body of man, animals, and plants as well as in the interior of the earth (**Luke** 8:6).[122] Life itself was looked upon as an evanescent vapor (**James** 4:14).

The vengeance of God is frequently likened to the destructive power of fire. Thus we find His anger pictured as a consuming fire (**Matthew** 3:11; **Hebrews** 12:29; **I Corinthians** 3:15; **I Peter** 3:20).[123] The wicked condemned to hell are punished by everlasting fire (**Matthew** 13:50; **Revelation** 19:20; **I Peter** 4:12). The hell-fire (gehenna of fire), constantly burning in a valley South of Jerusalem, was used for the burning of dead bodies of beasts and criminals; thus it served to suggest the site of eternal torment "where their worm dieth not and the fire is not quenched" (**Mark** 9:44).[124] The early Christians were in awe of the power of fire (**James** 3:5; **II Peter** 3:10) which, according to their belief, could be controlled only by means of supernatural force (**Revelation** 14:18; **Hebrews** 11:34). Jesus uses the term fire as a symbol for his gospel (**Luke** 12:49).

Fire assumes diverse and vivid forms in the Scriptures. Thus we find it pictured as breastplates (**Revelation** 9:17), as a lake of fire (**Revelation** 19:20), as "pillars of fire" (**Revelation** 10:1), and as "tongues parting assunder, like as of fire" (**Acts** 2:3).

The allusion to a pillar of cloud preceding the people traversing the wilderness stems from the custom of carrying braziers containing burning wood at the head of the caravan. The smoke by day and the fire by night served as an indication of the direction of march.[125] Smoke was regarded as a vapor (**Acts** 2:19).

The phrase "salted with fire" (**Mark** 9:49) conveys the idea of the purifying action of fire; interpreted from the theological point of view, this statement indicates the conquest of sin by a life of self-denial. "He that cometh after me shall baptize you with the Holy Ghost and with fire," according to some authorities, connotes the act of purification (**Matthew** 3:11).[126] Generally speaking, the concept of baptism with fire is variously interpreted. Some consider it the fire of hell, others that of the Holy Spirit, and still others, the fire of penitence. Some heretics abided by its literal meaning and actually used fire in the ceremonial associated with baptism. Fire is frequently contrasted with water, thus distinguishing spiritual from material baptism. Fire often symbolizes vengeance, destruction, severe trial, misfortunes, or punishment beyond the grave (**Luke** 9:49; **I Corinthians** 3:13, 15; **I Peter** 4:12; **Matthew** 5:22; 13:50; **Mark** 9:44).[127] The fire of coals alluded to by John (**John** 18:18) was probably a chafing dish of charcoal.[128]

The Hebrews used for the source of fire a variety of woods including chaff, chopped straw, the refuse from the threshing floor (**Matthew** 3:12),[129] and dried herbs (**Matthew** 6:30; **Luke** 12:28). Several metaphors are built upon the use of coal; among these the act of heaping "coals of fire" (charcoal) on the head of an enemy signifies a mode of revenge intended to awaken "pain of remorse in his breast."[130]

Ashes were the symbol of mourning. To defile the body with "dead objects," such as ashes or dirt, was a common practice among the Orientals and the Greeks. Thus in Homer's "Iliad" we find an account of the effect on the announcement of the death of Patroclus upon Achilles:

> "Grasping in both hands
> The ashes of the hearth, he showered them o'er
> His head and soiled with them his noble face."[131]

The application of fire for the working of metals, for the burning of incense, for home use, and for industrial processes has been considered in preceding sections.

Rust is mentioned twice in the New Testament. The term, however, cannot be given the modern inter-

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[118] M'CLINTOCK AND STRONG, *op. cit.*, Vol. 1, p. 639.
[119] Additional references to water (figuratively mentioned or otherwise): **Matthew** 10:42; 14:25; 27:24; **Mark** 6:48; 9:41; **John** 4:10, 14, 15; 5:3; 6:19; 19:34; 21:13; **Luke** 8:23; **I Corinthians** 3:6; **I Peter** 3:20; **II Peter** 2:17; **I John** 5:6; **Revelation** 7:17, 22:17).
[120] WHEELER, *op. cit.*, "The Gospels," p. 104.
[121] VINCENT, *op. cit.*, "James," Vol. 1, p. 752.
[122] VINCENT, *op. cit.*, "Luke," Vol. 1, p. 330.
[123] CHEYNE AND BLACK, *op. cit.*, Vol. 2, p. 1523.
[124] WHEELER, *op. cit.*, "The Gospels," p. 55.
[125] CHEYNE AND BLACK, *op. cit.*, Vol. 3, p. 3775.
[126] WHEELER, *op. cit.*, "The Gospels," p. 100.
[127] M'CLINTOCK AND STRONG, *op. cit.*, Vol. 1, p. 652.
[128] WHEELER, *op. cit.*, "The Gospels," p. 183.
[129] CHEYNE AND BLACK, *op. cit.*, Vol. 1, pp. 854–5.
[130] CHEYNE AND BLACK, *op. cit.*, Vol. 1, pp. 854–5.
[131] VINCENT, *op. cit.*, "Luke," Vol. 1, p. 351.

pretation. The rust alluded to in the sermon of the mount signifies any substance which brings about corrosion or deterioration (**Matthew** 6:19–20). In the passage "Your gold and silver is cankered; and the rust of them shall be a witness against you" (**James** 5:3),[132] rust is best interpreted as a tarnish which overspreads the precious metals. Ancient gold and silver coins, it appears, were susceptible to corrosion due to the presence of a large quantity of alloying metals.[133]

DIOSCORIDES

The New Testament contains but little information with reference to the large number of organic substances with which the ancients were acquainted. Among these products, either found free or readily isolated from the natural sources, may be mentioned mineral oils, asphalt, oily substances from varieties of coniferae, turpentine, plant oils (olive oil and oil of bitter almonds, for example), animal fats from domesticated and wild animals, fish and liver fats, lanolin, soaps, unbleached and bleached wax, starches from various types of grain, sugars (honey, and probably sucrose), dyes, and many others, too numerous to list.

Dioscorides, about the middle of the first century of the Christian era, wrote a voluminous treatise dealing with botany and pharmacy. The medical properties of several hundred plants are described by this botanist and military physician. The work was destined to become an outstanding reference of pharmacological properties of naturally occurring substances. Even as late as the sixteenth century did it serve in this capacity. Its content is not reserved for organic substances alone. Thus, the preparations of some simple inorganic compounds also are indicated (*i. e.*, the production of mercury from cinnabar and of potash from tartar). The earliest record of the preparation of mercury from cinnabar is to be found, however, in an account by Theophrastus and dates back to the year 300 B.C.[134] Dioscorides describes what may be considered as the very first example of wet analysis—the test for the presence of iron vitriol by means of gall-nut juice.[135] The extraction of fatty oils from seeds and fruits by pressing or boiling with water, as well as the distillation of turpentine (the resin of pine) to yield oil of turpentine were commonly known procedures.[136]

CHEMICAL THEORY

The absence of chemical theory in the New Testament is noteworthy. The only sign of the beginnings of speculative thought in science appears in the word "elements." Many of the Greek Fathers of early Christianity lived at Alexandria and they were, no doubt, influenced by the Alexandrian School of thought. The scientific work at Alexandria was under the leadership of men of Greek ancestry who were dominated by the philosophies of Plato, Aristotle, and Empedocles. Consequently some of the ideas of the ancient Greek philosophers found their way into Christian theology.

The Greek Fathers of early Christianity must have been acquainted with the famous hypothesis of the four elements—earth, water, air, and fire—as set forth by the Sicilian philosopher, Empedocles (450 B.C.). The word "elements" in the passage, "But the day of the Lord will come as a thief in the night; in the which the heavens shall pass away with great noise, and the elements shall melt with fervent heat, the earth also and the works that are therein, shall be burned up" (**II Peter** 3:10), may be interpreted in terms of the theory of Empedocles. In later times the term "element" was applied to the planets and signs of the Zodiac.[137] The origin of the concept that every element has its own god is to be found in the philosophies of the East.[138] The Hebrew concept assigned angels or spirits to fire, wind, clouds, and stars (**Revelation** 7:1; 14:18; 16:5; 19:17). However, the meaning of "elements" in "held in bondage under the elements of the world" (**Galatians** 4:3) and in "How turn ye back again to the weak and beggarly elements" (**Galatians** 4:9) is quite different; here it signifies "spirit," "demon," or "cosmic spiritual being."[139]

MAGIC, MIRACLES, AND SCIENCE

The "Book of Enoch," the longest and the most detailed of all the pseudepigrapha, is ascribed to the Biblical Enoch (**Genesis** 5:21, 24). Evidence available, however, indicates that it was written by different authors during the first and second pre-Christian centuries. In its present form it is a compendium of many Jewish works. The book describes the journey of Enoch to the kingdom of God, where he became acquainted, among other things, with the secret of nature. The Ethiopic version tells a tale about fallen angels who married mortal women and taught mankind the art of magic. The latter version leaves some room for conjecture about its possible bearing on alchemical beliefs. Mention is made of "seven mountains of magnificent stones" and" seven mountains full of choice aromatic trees and cinnamon and pepper." The writer, in the manner of the Revelation exclaims, "There mine eyes saw all the hidden things of heaven that shall be, an iron mountain and one of copper, and one of silver, and one of gold,

[132] VINCENT, *op. cit.*, "James," Vol. 1, p. 759.
[133] M'CLINTOCK AND STRONG, *op. cit.*, Vol. 9, p. 179.
[134] VON MEYER, *op. cit.*, p. 16.
[135] SARTON, G., "Introduction to the History of Science," Williams and Wilkens Company, Baltimore, 1927, Vol. 1, pp. 258–9.
[136] VON MEYER, *op. cit.*, p. 19.
[137] VINCENT, *op. cit.*, "Peter," Vol. 1, p. 706.
[138] CHEYNE AND BLACK, *op. cit.*, Vol. 2, pp. 1258–61.
[139] CHEYNE AND BLACK, *op. cit.*, Vol. 2, pp. 1258–61.

and one of soft metal, and one of lead."[140] In the Greek fragment, pharmacy is regarded as related to magic, mining, manufacturing of armor and weapons, and the "writing with ink and paper." Nearly all the writers of the New Testament were probably familiar with the "Book of Enoch" and, what seems more important, were influenced by its teachings.

A new heretical sect made its appearance during the early years of the reign of the Roman emperor, Marcus Ulipus Trajamis (53–117 A.D.). The followers of this cult invoked the seven witnesses—heaven, water, holy spirits, angels of prayer, oil, salt, and earth.[141]

Jesus condemned magic and exhorted the apostles to reject supersitition, invocations, and magic potions. Yet the belief in magic persisted. While sorcery was condemned (**Acts** 8:9, 13:6; **Revelation** 18:23; 21:8; 22:15), nonetheless, passages such as "They shall take up serpents; and if they drink any deadly thing, it shall not hurt them; they shall lay hands on the sick, and they shall recover" (**Mark** 16:18), if interpreted literally, are strongly reminiscent of the Egyptian, Alexandrian, and Neo-Platonic belief in magic.[142] That many followers of Jesus were heedful of his advice with regard to the practice of magic is shown by the quotation, "Many of them also which used curious arts brought their books together, and burned them before all men" (**Acts** 19:19).

In one of the apocryphal gospels of about the fourth or fifth century, we find accounts of many miracles performed by the Christ child. Thus according to the gospel of the Pseudo-Matthew, the child Jesus, while in a dyer's shop, took all the cloths waiting to be dyed with different colors and mischievously cast them into a furnace. Upon withdrawal of the garments, which evidently resisted the destructive action of the fire, the cloths were found to be the desired colors. Another account, found in the apocryphal legend of St. John, relates John's transmutation of the pebbles on the seashore into gold and precious stones. The latter feat persuaded the alchemists of the middle ages to the belief that John possessed the secret of the philosopher's stone.[143]

The New Testament is rich in accounts of miracles. Among them we find records according to which Jesus cured the blind (**Matthew** 9:27–30; 20:30–34; **Mark** 8:22–23; 10:49–52; **John** 9:1–7; **Luke** 18:35), healed the deaf and dumb (**Mark** 7:32–37), multiplied the fishes (**Luke** 5:1–9; **John** 21:1–8), relieved infirmity, dropsy, and paralysis (**Luke** 13:11–13; 14:2–4; **Matthew** 9:2–6; **Mark** 2:3–12; **Luke** 5:18–25), cleansed the lepers (**Luke** 5:12–13; 17:12–19; **Matthew** 8:2–3; **Mark** 1:40–42), changed water into wine (**John** 2:3–11), restored potency (**John** 5:3–9), revived the dead (**John** 11:38–44; **Matthew** 9:24–25; **Mark** 5:38–42; **Luke** 8:49–55), tamed the demoniac (**Matthew** 8:28–32; 12:22; 17:14–18; **Mark** 1:23–26; 5:2–13; 9:17–25; **Luke** 4:33–35; 8:27–33; 9:38–42; 11:14), rejuvenated the withered hand (**Matthew** 12:10–13; **Mark** 3:1–5; **Luke** 6:6–10), stilled the tempest (**Matthew** 8:24–26; **Mark** 4:36–39; **Luke** 8:22–24), and walked on the sea of Galilee (**Matthew** 14:25; **Mark** 6:48; **John** 6:19).

Jesus granted the power to perform miracles to his disciples (**Mark** 16:17), and St. Paul includes miracles among the "spiritual gifts" (**I Corinthians** 12:28). The spiritual healing of the sick as practiced by the followers of Christian science, as well as the faith healing as excercised by Catholics and Protestants today, must be regarded as miraculous. Although modern science has been skeptical of miracles, Christian philosophy permits supernatural phenomena. Be this as it may, the close connection between the beliefs in magic and miracles is self-evident. In a sense magic includes the early concepts of natural and spiritual phenomena and is regarded by some as the prescientific stage of understanding the working of nature and its influence upon the faith of man. According to the views of primitive man, the natural forces, the working of which he did not understand, were controlled by demons, deites, and the like. Alchemy, astrology, and witchcraft teem with these supernatural beings. Miracles, on the other hand, are phenomena which defy explanation by means of natural laws; the basis for their existence rests upon theological and not upon scientific reasoning.

As previously stated, the early Christian leaders were influenced by the speculations of the ancient Greek philosophers as well as by the contents of the "Book of Enoch." The Neo-Platonic and Alexandrian belief in magic makes its appearance in the tenets of the Christian religion. Even the concept of the Philosopher's stone, the potent transmuting agent of the alchemists of the middle ages, may have had its origin with the belief in occult arts. While magic may be associated with the origin of science, its theories and procedures are the very opposite of the spirit embodied in modern science. Civilizations characterized by a profound belief in superstition and magical power are weak in scientific accomplishment; cultures rich in scientific achievements bar the existence of magic. Neo-Platonism readily accepted the superstitions of astrology and necromancy and with it many of the secret rites. It is therefore not surprising to find tinges of more primitive magic rites (*e. g.*, communion and sacrifice) in the dogma of the Christian Church. While modern science precludes the practice of magic and is skeptical of the existence of miracles, Christian doctrines include the latter manifestations. The difference in the point of view of science and religion is readily understandable. According to science, the universe is subject to

[140] THORNDIKE, L., "The History of Magic and Experimental Science During the First Thirteen Centuries of our Era," The Macmillian Company, New York, 1923, Vol. 1, pp. 341–7.
[141] THORNDIKE, *op. cit.*, Vol. 1, pp. 372–3.
[142] *Ibid.*, Vol. 1, p. 386.
[143] *Ibid.*, Vol. 1, pp. 387–98.

scientific laws and the occurrences taking place in it can be explained by means of natural causes; Christianity believes that the ultimate reality of the the universe is spiritual rather than material, and further, that God's law is an expression of His will which exercises ultimate control over His creation beyond the understanding of mere man. Keeping these differences in mind, little if any scientific speculations should be hoped for in the New Testament. Magic, evidence of which is found in the Scriptures, must be looked upon as the predecessor of both religion and science.[144]

[144] The reader interested in brief but scholarly discussions dealing with the connection between magic, religion, and science will find pp. 28, 42, 45, 57, 68, 89, 155, 158, 375–7, and 381 in SIR WILLIAM CECIL DAMPIER'S "A History of Science," The Macmillan Company, New York, 1943, instructive reading.

Note on Teaching the Metric System

G. WAKEHAM

University of Colorado, Boulder, Colorado

FOREIGN languages used to be taught by the "vocabulary-translation" system. Lists of native words were matched with their alleged foreign equivalents, and translations "both ways" were used to grind in the new tongue. Untranslatable idioms and more subtle semantic fallacies were sidestepped or ignored. Students rarely learned to *think* in the strange medium.

It was the writer's good luck, as a young child, to attend for a short time one of the very few pre-Dewey progressive schools. We heard the heavy footsteps of the approaching professor, rhythmed to the deep hum of a melodious *Brumbass*. Six feet tall and heavily whiskered, he was appallingly overpowering. Picking up the nearest convenient object, he bellowed, "BUCH! Das ist ein BUCH!" Then, after a short but impressive pause, "Was ist das?" Shivering in our shoes, and to avert imminent catastrophe, we piped up, "Buch!" Plucking a rose from his lapel, he sang, beautifully, one line of "Röslein, Röslein, Röslein rot," and bellowed, "SING!" We sang. Holding the book and the rose together, he announced, "Buch rot. Rose rot!" We got it. And we never *forgot* our German. Modern progressive language teachers use similar, if somewhat less violent, techniques.

Science teachers and texts, however, still cling to the ancient vocabulary-translation method. Students learn the names of the metric units and then memorize their approximately equivalents in the barbarious measures of common usage. These figures are distressingly complex and irregular, the actual ratios, of course, being incommensurable, unless one arbitrarily defines one system in terms of the other. Students work numerous "translation" problems and always, in their own minds, laboriously convert metric-system data into the familiar units. They rarely learn to *think* in grams, centimeters, and degrees Centigrade.

The modern, progressive method, of course, is to junk the medieval, "English" system at the outset, and start with a metrical *tabula rasa*. Urge the students to forget feet and inches, pounds and ounces, pints and Fahrenheits, and enter the new field of science-measurements with clean consciences. Then show them a meter-stick, and explain that it is about one ten-millionth of the distance between the equator and the north pole. Do *not* obfuscate the class at the outset by stating that this ratio is not exact: an "exact" determination of the ratio is, in any case, impossible. Stick to the main point of the demonstration, ignoring all confusing, minor considerations.

It is an unfortunate accident that the meter looks like a yard. If you can get by with it, ignore the yard. If some persistent reactionary points out the similarity, put him in his place by reminding him that he has not followed the original instructions to *forget* the yard, along with all of its relatives. Do not say whether the meter is more or less than a yard: the less said about the yard, the better. The *meter* is the thing you are talking about.

When the meter has been sufficiently emphasized, have the students estimate familiar magnitudes—the dimensions of the room, the length of the corridor, the height of the teacher, etc.—in meters. Do not bring in rods or miles or any of the discarded heathenisms.

With the meter once fixed, it is easy to go on to the other units. The dimensions, volumes, etc., of various pieces of apparatus should be learned from demonstrations. It is unnecessary—in fact inadvisable—to learn the whole metric system with its rarely used decimeters, dekameters, hektometers, and what-not. Three units each of length, volume, and weight suffice for all common purposes: meter, centimeter, millimeter; liter, milliliter, cubic millimeter; kilogram, gram, milligram.

Probably the most effective method of enticing the students to *think* in the new medium is to require them to guess the magnitudes involved in various common objects, such as a brick, an egg, a pencil, a teaspoon, a cup, their own dimensions, etc. Some, of course, will betray their lack of imagination by offering hilarious "guesstimates" of their own sizes—anything from an ant to a silo. But even these blunders can be used to stimulate imagination, and the skillful teacher may even perpetrate a howler of his own to cover the confusion of a sensitive student. Only after they have learned to move about easily and freely in the new medium should students be given "translation" problems which rarely have any practical necessity.

An Apparatus for the Preparation of Tellurium Tetrachloride

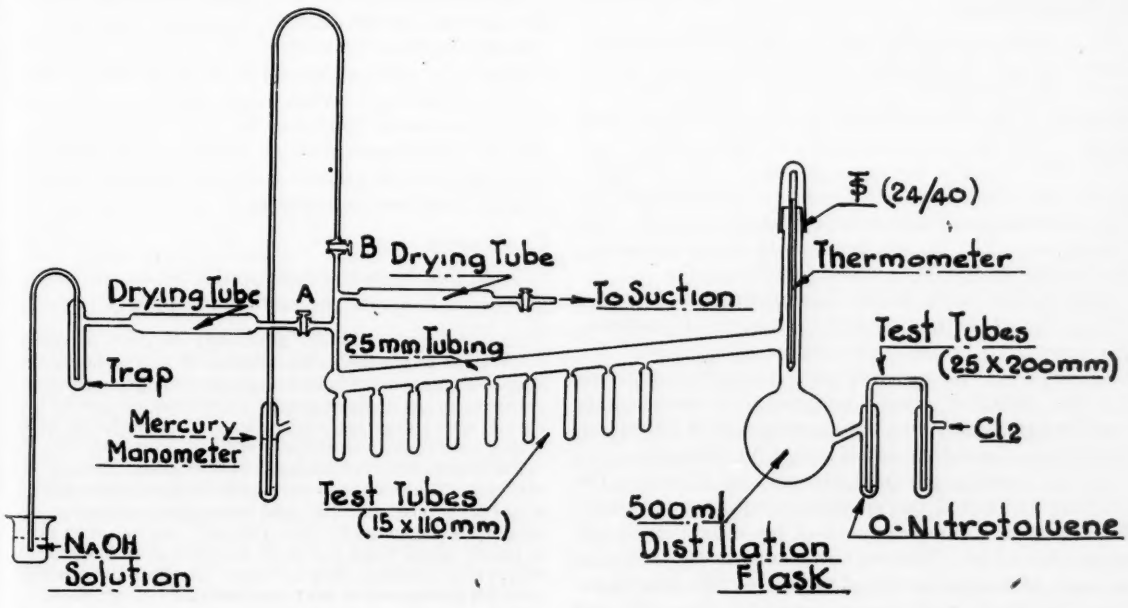
JOHN F. SUTTLE and ROBERT P. GECKLER
Indiana University, Bloomington, Indiana

IN THE preparation of organo-tellurium compounds tellurium tetrachloride is often used as the source of tellurium. One of the simplest preparations of tellurium tetrachloride involves the direct chlorination of elemental tellurium;[1] however, in the preparation and preservation of an easily hydrolyzable substance like tellurium tetrachloride a great deal of care must be taken in the apparatus and technique used. The apparatus described below is made completely of pyrex glass and can be made by anyone with a little experience in glass blowing and the proper equipment.

In a typical run, 85 grams of oven-dried tellurium (suitable tellurium may be made by reduction of a hydrochloric acid solution of tellurium dioxide with sulfur dioxide) is placed in a previously dried 500 ml.-distillation flask. The 24/40 ⅎ joint is greased and then closed. The apparatus is now evacuated, and while connected to the source of vacuum, is carefully heated by means of a Bunsen burner to dry further the tellurium and the apparatus. Chlorine is introduced at a moderate rate after the evacuated system is shut off from its source of vacuum. A few drops of *o*-nitrotoluene is placed on the surface of the mercury in the manometer to protect it from the chlorine; however, by only occasional use of the manometer through manipulation of stopcock *B* the use of an inert liquid on the surface of the mercury may be avoided. The same liquid was used in the bubbler indicating qualitatively the flow of chlorine.

The application of heat to the tellurium is unnecessary until the reaction mixture liquefies. In about two hours liquefaction of the reaction mixture to a black liquid begins. The inside pressure is approximately atmospheric by then. The introduction of the chlorine is continued and stopcock *A* is opened to allow any excess of chlorine to be absorbed by the sodium hydroxide solution. Until an excess of chlorine has been added the liquid and its vapor will be very dark brown or black due to the presence of tellurium dichloride. During the final part of the reaction when the mixture is liquid in character, the flame from a Bunsen burner is gently applied to the reaction flask.

[1] SIMONS, J. H., "The properties of tellurium tetrachloride," *J. Am. Chem. Soc.*, **52**, 3488 (1930).



When the liquid becomes amber in color the introduction of the chlorine is stopped.

The system is evacuated again and allowed to remain on the vacuum line. The application of heat is carefully continued until enough of the liquid has distilled over to fill the first ampule two-thirds full. The ampule is then sealed off. During this distillation the material will tend to solidify in the 25-mm. tube to which the ampules are attached and must be melted frequently in order to facilitate flow of the product into the ampules. The succeeding ampules are filled and removed the same way. Tellurium tetrachloride does not interfere with the working of the glass, so little difficulty is encountered in making the seals.

From this run, nine sealed ampules each containing between 15 to 20 grams of tellurium tetrachloride can be obtained. The tellurium tetrachloride will remain stable at room temperature in the sealed ampules.

Out of the Editor's Basket

A BULLETIN (Number 27) of the Office of Scientific Personnel discusses the slightly liberalized policy of Selective Service in regard to technical workers, and also a recent War Department Circular which gives some hope for priority of discharge of trained scientific personnel. It continues:

> It is interesting to note that the Selective Service release and the War Department release both finally recognize that policies based only on the immediate occupation of the individual or his personal rights and ignoring his value to the community by reason of his training or potential, cannot in the long run endure against the need of a technological society for specialized personnel. It is an admission that trained minds are a national asset, which fact must be reflected in sound policy. This recognition having once been made, it seems likely that the broadening of the policy to cover categories now missed will follow.

In Recognition

The public usually is slow to recognize accomplishments in the field of fundamental science. An exception to this was the recent public citation of Dr. Glenn T. Seaborg by the Chicago Junior Association of Commerce as the outstanding young man of Chicago for 1945.

Dr. Seaborg, who has been on leave to the Metallurgical Laboratory from the University of California for the past four years, discovered plutonium in 1940. The announcement of his discovery, with three coworkers, of elements 95 and 96 was made last November.

Thirty-three years old, Dr. Seaborg has been in charge of the research at the University of Chicago for separating plutonium in amounts and purity required for war purposes. He has also been primarily responsible for the chemical separation procedures which were used in connection with the manufacture of plutonium at Clinton, Tennessee, and Hanford, Washington.

While working at the University of Chicago, Dr. Seaborg conducted the chemical identification studies leading to the announcement of his discovery of elements 95 and 96. The two new elements were found as a result of bombardment of uranium 238, the abundant isotope of that element, and plutonium 239 with high energy helium ions, or alpha particles, of 40 million electron volts in the cyclotron at Berkeley, California. The identification studies, conducted in the Metallurgical Laboratory, involved the usual extensive requirements of proving that the chemical properties of the two new elements are different from those of all other 94 elements.

Dr. Seaborg is also the codiscoverer of neptunium 237, a new isotope or twin of element 93, neptunium, and the only isotope of neptunium that has been isolated in pure form. His neptunium 237 has a half-life of two million years and is relatively stable in comparison with the first known form, neptunium 239, which has a half-life of 2.3 days.

Education-Industry Program

The Committee on Cooperation with Education of the National Association of Manufacturers (14 West 49th Street, New York 20, N. Y.) has issued a bulletin entitled "A Digest of Nation-Wide Education-Industry Action Programs." While particularly concerned with the lower schools, there may be some ideas in it for application at higher levels. Of course, we are aware that some people will consider industry's interest in education as "insidious propaganda."

Leadership

From *The Foreman's Letter*, published by the National Foremen's Institute, we quote the following:

> New miracles of science, astounding in their potentiality await us all and befuddle the thinking of a great many of us. Faced with prospects of radical change in techniques and methods promising an age of abundance for all, it is not too rare for guessing and speculating men in all walks of life to doubt the validity of their present-day interests and their past experience.
>
> Yet, somehow we are reminded of the famous football coach who said, "You can have your A, your T, your single- or double-wing back formations. For good measure you can have a repertoire of 200 plays as well. Me? I'll take 11 big men (and a couple of spares) all of whom can block well enough to keep the other fellows from scoring as often as we do. You keep the new fangled stuff, I'll put my faith in the fundamentals."
>
> And so it will go in the modern plant, Atomic Age or no. Man will still push the buttons, and assemble, test, and repair the mir-

acles when they break down. The foremen of those men will continue to supervise and guide by applying the fundamental principles of leadership.

Fire!

The plastics and chemicals world to which the consumer looks for new comforts for everyday living is bringing increased safety to individuals and property, and some of the fears expressed by fire fighting authorities and public safety administrators are completely unfounded. Dr. Foster D. Snell recently gave a striking demonstration before a meeting of fire chiefs. With two assistants he demonstrated—on white rats—the effects of toxic gases present in fires produced by household materials used for years, to point up the relative safety of newer and less familiar substances.

The average householder will be astounded to know that such common, everyday substances as newsprint, steak, milk, clothing, and wood produce toxic gases if burned under certain conditions. Dr. Snell told his audience: "The new things you have been hearing about are. . . decomposed by burning into exactly the same materials as the old products you have dealt with the last hundred years. In many cases the new products, plastics or solvents, as examples, are less of a fire hazard than the more familiar products they supersede."

Illustrating his points, he exposed white rats without harm to toxic gases in concentrations that would be encountered in normal fire conditions. Demonstrating the difference between fire conditions where there is an air supply and high-temperature heating in the absence of an air supply, he called on one of the audience to provide him with a newspaper. Pieces of this paper were heated in a closed container and a white rat was exposed to the gases produced and was quickly suffocated and died.

In a fire, materials may burn to carbon dioxide and water, if there is an ample excess of air. With less air, partial combustion takes place and carbon monoxide is produced. If the material which is burning is nitrogenous, it may burn completely to give elementary nitrogen or compounds of nitrogen, but almost never to give oxides of nitrogen; or it may decompose to a lesser extent and some of the nitrogen be present as hydrogen cyanide.

"The facts about cyanide," said Dr. Snell, "are that if you try to poison an animal with it, you have to use a tremendous amount. To kill rats and roaches, it is customary to use about 1000 parts per million. In a fire where there is sufficient air to support combustion, the cyanide will be diluted to an extent that it is not lethal to man, and the same air currents that carry away the smoke of the fire will disperse the gases.

"Any time a nitrogenous material is burning without a substantial excess of air, there is cyanide gas present. A fire which involves the burning of cheese and milk products and anything which has combined nitrogen in it produces cyanide gas. There is a detectable amount of cyanide gas given off when you broil a beefsteak because the beefsteak is a nitrogenous compound and it is heated to a temperature at which the nice black part on the surface which we like so well is due to decomposition.

"Although people are particularly frightened of cyanide, there are quite a number of materials which, on the basis of U. S. Public Health Service standards, are more dangerous than cyanide. The three most dangerous gases are arsine, chlorine, and ozone, of which fortunately only chlorine can exist in the presence of fire. Chlorine is its own indicator and is so unpleasant that if a person can move, he will get away from it before it can be dangerous."

Temperature Colors

The gas turbine, powerful combustion engine which since development has refused to have its temperature taken, has been forced literally to take its own temperature by General Electric engineers through use of a special metal alloy which tells temperature by color.

The alloy, a chrome-cobalt composition, shows a marked color change for every 25-degree change in temperature from 500° to 700°C., then reverts back to its original color and begins the color scale over again in a higher range of from 725° to 900°C. (1652°F.). This is believed to be the highest temperature ever recorded accurately inside a gas turbine.

The temperature-taking alloy turned the tables on the gas turbine after practically all types of temperature-measuring devices had failed to record faithfully the intense and varied heat created by the turbine wheel which whirls more than 1000 miles per hour.

By making turbine parts of the alloy, the turbine has no alternative but to take its own temperature. Following operation, the turbine has to "show its colors," and by doing so, also has to show its temperatures reached during operation.

The chrome-cobalt alloy, like most metals, changes color when being oxidized under heat. Unlike other metals, however, this alloy oxidizes so slowly at higher temperatures that each color change occurs regularly at 25-degree intervals, thus permitting an actual graduated color scale according to temperature.

But the strangest characteristics of the alloy is that after it completes one order or scale of colors, it reverts back and repeats these colors in a second order in a second, higher range of temperature.

On the basis of one hour of heat treatment, the alloy at 500°C. turns a light straw color, at 525° a straw color, at 550° a bronze color, at 575° purple, at 600° dark blue, etc. The alloy turns light blue at 700°C., and according to all precedent, it next should turn gray, indicating the end of the color scale.

Instead of turning gray, however, the alloy at 725°C. reverts back to a light straw color and begins the progression of colors over again. The alloy turns light blue in the second scale when it reaches 900° and begins to show graying tendencies at 925°, the engineers report.

Interference colors of the alloy change as the thickness of the oxide film changes, until the oxide film becomes so thick or irregular that no color is transmitted

through it to be reflected. At this point, indicated by a dull gray surface, oxidation has run its gamut of colors, and the metal is no longer useful as a yardstick for measuring temperature.

Demonstrating just how fine a change actually takes place, the film of oxide on the alloy increases in thickness only two and one-half billionths of an inch at every 25-degree change in temperature. By comparison, 12,000 such thicknesses would be necessary to attain the thickness of a single sheet of ordinary writing paper.

Job for Chemist

It is interesting to note that the new Shippers' Research Division created by the Air Transport Association of America is to have as its Director "an expert chemist, experienced in both general and laboratory work."

ATA already has made tentative arrangements with an independent laboratory to carry on experiments for the division; however, research work to be carried on regarding pressure chambers and other stratospheric factors will require additional facilities.

The duties of the new division first will be to study present air cargo items and their relation to pressure changes (due to altitude), corrosive properties of materials with respect to aluminum alloy aircraft, and light weight packaging. This program eventually should result in the publication of governmental and tariff regulations, affording both shipper and carrier condensed, accurate, and uniform regulations covering the transport of airborne articles of virtually every description.

In announcing the formation of the new division, ATA officials said, "We recognize that many materials may be carried by air if properly packaged, although under present inadequate regulations, the carriage of these materials may be questionable; therefore, all classes of hazardous materials should be studied with a view to the methods of safe packaging and handling.

"Among the miscellaneous items whose development we feel should be desirable are a vaporproof self-pressure equalizing container for flammable liquids, and possibly a second vaportight can for paints and pigmented materials which fall in the inflammable class.

"Another is a good absorbent material for packing containers of liquid, and some consideration should be given to the possibility of using unbreakable glass bottles for certain materials."

Aluminum

Aluminum emerged from the war a better metal for many new purposes and is now available at the lowest price in history. Manufacturers and fabricators plan to take advantage of these conditions to utilize efficiently not only the enlarged production facilities for primary aluminum but the heavy supply of scrap now available. Estimates of the supply of aluminum scrap range from one to three billion pounds.

As evidence of the growing acceptance of aluminum for new applications, a trend the industry hopes to accelerate during the coming year, the industry will depend for volume, in part, upon applications comparatively little known until now in a number of the nation's largest industries. New types of roofing sheet to tap a tonnage market are now being introduced to the building industry and should account for hundreds of millions of pounds. A new aluminum roof now nearing completion for the Union Terminal at Cincinnati will require 85,000 pounds of the metal.

The nation's railroads, seeking modern, more attractive, and lighter equipment, are specifying aluminum in many applications for 1946. Of 1100 rail passenger cars now on order, 160 will be of all-aluminum construction, and the others will average between 2000 and 10,000 pounds of aluminum per car. Engineers are also calculating the lightening of such specialized railroad equipment as trucks, brakes, air-conditioning equipment, and lighting systems. Even locomotives in 1946 will employ large amounts of the light metal. The Pennsylvania Railroad has 50 new type locomotives under construction which will average 10,000 pounds of aluminum each for cabs, walkways, and boiler coverings. Other forms of transportation, such as trucks, trailers, buses, and airplanes will employ large quantities of aluminum.

Among smaller items already in volume production is a line of aluminum canoes weighing only one-half to two-thirds as much as their counterparts made of other materials. Some of the new packaging applications developed during the war will have postwar applications. Aluminum caps and seals made for penicillin bottles will have peacetime counterparts in packages designed for pharmaceutics, while heat-sealed aluminum foil envelopes used during the war will protect and display such products as dehydrated soups and powdered fruit juices.

Rubber Uses

Motorists were not the only group hit hard by the lack of natural rubber, for the chemical engineers, too, watched the diminishing stockpiles of rubber with apprehension. Even while they were battling to create the vast synthetic rubber industry, the nation's engineers of the chemical industry were experimenting with their products for applications in chemical plants. These facts were brought out by M. G. Fontana, in a paper before the American Institute of Chemical Engineers recently.

For example, viscose rayon and cellophane plants were critically dependent upon molded rubber parts and rubber roll coverings for successful operation. It was fortunate that synthetic rubber was quickly produced in large quantities in this country and that the synthetic rubbers proved satisfactory. The conversion from natural to synthetic rubber was urgent and sometimes quite critical.

The first application of Buna S rubber in lining a tank of commercial size was in October, 1943. Several hundred thousand square feet of Buna S linings have been installed in tanks, lines, and valves handling

process water and dilute sulfuric acid. Buna S gaskets were also used successfully.

Buna N, another type of synthetic rubber, has been used in the printing industry because its resistance to solvents used in inks make it suitable for printing rolls. This property also makes it valuable in making wax paper.

Neoprene solved several tough problems for the engineer. By impregnating glass cloth with this product, conveyor belts handling hot corrosive chemicals were made to last seven months, where previously the best life was six weeks.

Platinum Metals

Supplies of platinum, since the close of the war, have not been adequate to meet the pent-up civilian demand. United States stocks of platinum in the hands of refiners, dealers, and importers when the war ended were below normal.

Throughout the war period, domestic production of primary platinum, including Alaskan, was relatively small as compared to United States requirements. Most of our requirements came from Canada, which also supplied the major portion of palladium, rhodium, and ruthenium. Colombia and Russia supplied important quantities of platinum.

The merit and value of the platinum metals for industrial purposes is demonstrated by the following figures compiled by the United States Bureau of Mines, showing the use of the platinum metals during the first six months of this year:

	Platinum	*Palladium*	*Other platinum group metals*
Electrical and chemical industries	165,000	40,000	7500
Dental and medical purposes	15,000	22,000	...
Jewelry	...	37,000	...
Total	180,000	99,000	7500

Palladium made great gains during the war as a precious metal for fine jewelry. The white color of palladium is used to advantage in settings for diamonds and other gems and in two-color combinations with gold. The lightness of palladium is utilized to eliminate excess weight from large brooches and other pieces. These advantages together with its strength and durability assure for palladium a place in fine jewelry along with platinum and gold. The public is being better informed on the preciousness of palladium, through extensive advertising and publicity, and is thus realizing that palladium is indeed the only truly natural "white gold."

Platinum metals are said to have contributed greatly to the winning of the war through their widespread use in military equipment and in the production of war goods. Large quantities of platinum were used for electrodes in airplane spark plugs, for contacts in magnetos, and in numerous instruments, including airplane flight controls, bombing equipment, and computing apparatus. Electronic devices, including radar, utilized the superior performance of platinum metals in various parts, one of the most notable being the use of platinum and platinum-clad grids in high-frequency transmission tubes. Platinum alloys played a vital role in the production of military explosives, being used as catalysts in manufacturing nitric acid, which is one of the principal raw materials in the production of such explosives. From platinum alloy spinnerets and bushings came the rayon and fiber glass used for so many varied war purposes. Insoluble platinum anodes produced the perchlorates, peroxides, and other chemicals obtained by anodic oxidation, and were employed in production of war equipment that involved electrodeposition of nickel, rhodium, or other metals. The innumerable instruments used in communications, in navigation, in automatic controllers, and in measuring and recording devices of many kinds utilized the exceptional corrosion and heat resistance of platinum metals as well as their electrical and mechanical properties.

Why Nothing Takes the Place of Glycerin

The following is taken from a bulletin with the above title published by the Glycerine Producers' Association:

In both industry and medicine glycerin plays a more comprehensive role than any other fluid except water. No one other product combines all the properties of glycerin, hence no satisfactory substitute has been found for the full range of its many applications. Its wholesomeness for human consumption makes it especially valuable in foods, drugs, and cosmetics.

The usage of glycerin in industry depends upon both chemical and physical characteristics. A trihydric alcohol with the formula $C_3H_5(OH)_3$, the structure of glycerin lends itself to numerous syntheses because of the easy reactivity of the OH groups. One example is the reaction of the OH groups with phthalic anhydride, making it useful in the production of solvents and softeners for plastics and lacquers, synthetic resins, and many of the new paint formulations.

Being a polyhydric alcohol, glycerin may be combined with any of a great number of acids to produce esters which have a variety of industrial and commercial applications. It may also be combined with alkalies and metallic oxides to form salts with unique properties. The oldest and perhaps the best example of a chemical derivative of glycerin is nitroglycerin, which finds very extensive use in dynamite and other explosives.

Newer derivatives which may be made available in commercial quantities are the chlorohydrins, glyceryl ethers, glycerin formal and bisformal, and many others.

One of the most generally useful properties of this fluid is its power to absorb and retain moisture from the air. This makes it helpful as a humectant in processing, where moisture content must be maintained or where it is desirable to avoid excess drying.

Glycerin also possesses high solvent power. Many substances, such as iodine, bromine, tannin, alkaloids, thymol, phenol, mercuric chloride, boric acid, fixed alkalies, etc., are more soluble in glycerin than in water. Major uses based on these solvent powers include drugs, cosmetics, perfumes, flavoring extracts, printing inks, polishes, textile dyeing.

Distilled glycerin is crystal-clear, very stable, and practically neutral. Having a high boiling point (290°C. or 554°F.), it resists evaporation. In water solution it has very low freezing points (as low as −51.11°C. or −60°F.), It does not turn rancid, and if used in proper proportions has a definite preservative action. These preservative powers probably are due to its hydroscopic action by which it deprives the organisms of water and causes dehydration of the bacteria.

Glycerin has "body" and this, together with the fact that it prevents other products from drying and hardening when exposed to the air, fits it for many uses in lubricants. In places where oil does not give the best results glycerin is useful either by itself or as a constituent of special lubricants.

Here and There in the Trade Literature

IF THE Nucleonics Issue (Vol. 24, No. 6) of the *Monsanto Magazine* isn't already out of print, you had better put in your request for one immediately, for it soon will be. It is entirely given over to the subject of nucleonics, is well illustrated, and has good articles by competent authorities. Theory and practice, historical background and personal anecdote, combine to make it an excellent, readable contribution to this popular subject. Three articles alone, which would make it well worth preserving, are: "Some implications of atomic power" by A. H. Compton; "Principles of atomic power" by J. C. Warner; and "Epoch in the desert," an eyewitness account of the trial blast at Alamogordo, by C. A. Thomas.

● Gulf's "Polyform process" is described in simple fashion, with a good flow diagram in color, in the November-December number of the *Orange Disc*.

● The November-December number of the *Humble Way* is an usually attractive one. It contains an excellent article on corrosion problems by the company's senior corrosion engineer, in which the theory and practice of cathodic protection are discussed. The work of laboratory glass-blowers comes in for some discussion, with some interesting illustrations. Another article, on natural gas, explains why this is becoming of increasing importance in the petroleum industry (courtesy of H. C. Weiss, *president*):

The newest and most spectacular use of some of the light constituents of gas is for the manufacture of chemicals. The hydrocarbons in natural gas, just as those of oil and coal, can be used to make a wide range of chemical products, including such things as synthetic ammonia, methyl alcohol, formaldehyde, and substances that can be used in plastics and synthetic rubber. While such uses are important, they can be supplied with a small fraction of the current gas production.

There is a potential use of natural gas that must also be considered; namely, the manufacture of liquid fuel from methane. Methane is very difficult to convert into liquid, but techniques have already been developed to manufacture synthetic gasoline and Diesel oils from methane by chemical synthesis. Plant designs for such manufacture are being improved rapidly and it may not be long before these products can be made from natural gas at costs competitive with the products from crude oil. This is particularly true in view of the chemical products that can be produced incidentally, which may provide a substantial by-product revenue, thereby reducing the cost of the synthetic gasoline.

● We recently received the *Plastics Newsfront* for the first time. Issued by the Plastics Division of the American Cyanamid Company, it is devoted to the most recent practical uses of these new materials.

● *Shell News* continues in its January number the series of articles on "Oil through the ages," this time dealing with the history of oil production in this country during the latter half of the 19th century.

[1] For the company and address of a magazine cited, see THIS JOURNAL, January, 1946, p. 38.

● The mining of salt is the entire topic of the November-December number of *Oil Power*. The story is told how the discovery of oil in commercial amounts in Pennsylvania was speeded by the complaints of salt-well operators that oil was seeping into their wells and ruining them. Oil-well drillers in Kansas were just as upset over the fact that they discovered salt where they had hoped to find oil.

● "Four million gallons per day" sounds like water. It is the title of an article in the December *Resinous Reporter*, concerning the treatment of water, particularly for refinery purposes, by the use of the modern "ion-exchange" resins.

● "Those invisible electrons" are followed in their actions by the well-known science writer, H. W. Blakeslee, in the January number of *Steelways*. An account of the many everyday services performed by the science of electronics is followed by this:

POSTSCRIPTS TO ATOMIC ENERGY

The atomic power expected from the bursting atoms of uranium and plutonium of the atomic bomb will, if it comes soon enough, put electronics into homes.

Electronics has not been offered for home uses on a large scale because of expense. This cost is not in the electronic tubes, nor in the mechanisms they operate. The expense is in the power required. This power is used in the form of high-frequency electric currents. High frequencies are comparatively expensive to produce.

The electronic devices, which save great sums of money in industry, monitor operations involving usually thousands or hundreds of thousands of dollars. In the home electronics cannot pay its way by producing profits.

But if power gets as cheap as the atomic dreamers hope, then high-frequency electrical current will become inexpensive. Then there will be electronic tubes to turn the lights on and off according to the outdoor illumination; tubes for cooking, washing dishes, laundering, ironing, dustless floor cleaning, air purifying.

Many of these electronic devices have not yet been made. Others already are in use in industry and their principles are well enough developed for adaptation to homes and farms whenever the cost drops to the point where there is a market.

● One of the most intriguing applications of radar was the VT, or proximity fuze, which consists of a tiny radio transmitter and receiver in the head of a shell. By the reflection of the microwaves as it approached its target the shell was exploded at the most effective instant. One sees accounts of this little instrument on every hand. One of them is in the Winter Edition of *Inco*.

● From an article in the January *Merck Report* entitled, "Important facts regarding hair," we quote the following, which has interest in connection with the chemistry of cosmetics:

Astbury, by means of roentgen-ray diffraction photographs, showed that hair is a molecular yarn. The molecular chains are composed of polypeptide linkages with numerous side-chains. Ordinary unstretched hairs are buckled so as to accommodate

the numerous interactions between these side-chains. When hair is stretched, a transformation of short to long molecules occurs. Water helps hair to stretch farther and more easily. A hair that has been stretched and dried hardly contracts at all; but once it is wetted it contracts again with amazing speed. This is the scientific basis of water waving. To get a permanent set, the hair must be stretched in very hot water for a considerable period of time, and this action is accelerated by means of alkalies. This can be performed with minimal damage by an expert. However, if a hair is stretched by about 50 per cent of the length, and steamed and stretched for several hours, the scale-sheath often breaks into short sections. These sections are so loose that they can be slid along the cortex-like rings on a curtain rod. Permanent waving can be accelerated by strong alkalies which dissolve the keratin. In addition to the physical damage incurred, the resulting set must be carefully nurtured and kept in place. For this purpose, there are various setting lotions, usually mixtures of nonvolatile alkalies, gums, and ammonia. The so-called "oil wave" is a mixture of ten per cent borax and potassium carbonate. These strong alkalies may break and split the hair shaft. The hair must be carefully kept in place following these applications, with the resulting accumulation of dry scales on the scantily brushed and combed scalp. It is unfortunate that one cannot make it mandatory for permanent-waving salons to display on their walls the dictum of Erasmus Wilson, "You cannot brush the head too much nor the hair too little."

From the preceding discussion of the molecular structure of hair, it can be readily understood that hair is elastic. Leftwich performed a series of experiments to determine how far hair could be stretched without breaking. He also determined the effects of some common toilet preparations on the elasticity and strength of the hair. The average hair breaks when subjected to a pull of seven ounces. With immersion in soft soap, it may break after a pull of four or five ounces. Permanently waved hair may break at four ounces or less, according to Savill. Variations are common with different types and thicknesses of the hair shafts.

● The first number of the *Sugar Molecule* (Sugar Research Foundation, 99 Wall St., New York 5, N. Y.) reached us recently. Its three pages are given over to the subject of amino acids from sugar. The discovery of a method for the "synthesis" of *d,l*-histidine fistidine from sugar is used as the occasion for a brief comprehensive discussion of the biochemical significance of amino acids in general.

● From the January *Westinghouse Newsfront* we quote the following:

SURFACE ATTENTION

The causes of rust and corrosion are hidden in a layer of atoms so minute that one hundred million of them stacked on top of one another would barely equal an inch. Yet Dr. Earl A. Gulbransen of the Westinghouse Research Laboratories has made thousands of photographs of such layers, weighed them accurately, and taken electron "portraits" that show their chemical nature.

The Westinghouse scientist is attacking one of the fundamental questions facing metallurgists, chemists, and other men of research: what actually happens in the invisible boundary zone that is formed when metal comes into contact with air, or when any solid reacts with a gas? Although Dr. Gulbransen is now concerned with collecting a mass of evidence on which to base his case, his studies are eventually aimed at providing ways to produce better tin plate, cheaper stainless steel, stronger gas-turbine blading, and longer-wearing bearings for engines.

To probe the atomic nature of the coatings or oxides that form on metals, Dr. Gulbransen uses three tools: the electron microscope, the electronic diffraction camera, and the vacuum microbalance. The first tells the scientist what the coating looks like physically; the second reveals its chemical nature; and the third measures the rate at which the coating grows.

The electron microscope enables Dr. Gulbransen to "see" the tiny film of atoms by magnifying it up to 50,000 times. This is done by means of a high-voltage beam of electrons that passes through the sample and is pulled outward by magnetic fields along the sides of the microscope. The magnified image, produced by two successive spreadings of the beam, is recorded on a strip of photographic film in the form of a shadowgraph.

In the diffraction camera Dr. Gulbransen again uses an electron beam, but this time he fires it at an angle to the sample so that it ricochets off and strikes against a strip of photographic film. The result is a pattern of black and white semicircles that are formed by electrons bouncing off the different faces of the blocklike molecules of the oxide coating. By measuring the distance between the rings, the scientist is able to identify the chemical nature of the oxide.

How quickly rust and tarnish are built up on a metal exposed to air is measured by the vacuum microbalance. This is a highly sensitive instrument constructed mainly of quartz and hairlike tungsten wire, and enclosed in a vacuum chamber. The sample to be weighed—a piece of steel for example—is hung on one end of the balance beam, while a counterweight is suspended from the other. Dr. Gulbransen then admits small amounts of oxygen into the chamber which form an oxide coating on the metal, making it gradually heavier. Movement of the balance beam is watched through a microscope, and the changes in weight are recorded every few minutes—usually in millionths of a gram.

By studying the atomic ingredients of rust, corrosion, and tarnish, the Westinghouse scientist hopes to produce a "recipe" for metals and alloys that will make them resistant to such attacks. Heretofore, the method of preparing such alloys has been a trial-and-error one, the constituents being mixed in a furnace and then tested under various conditions. Dr. Gulbransen aims at providing the metallurgical know-how for making the production of alloys an exact science.

● "Characteristics of oil-water emulsions" is one of the subjects in the January *Rig & Reel*. It deals with the subject particularly as it concerns problems in the production and uses of petroleum.

● The physical basis for qualitative and quantitative spectrographic methods of chemical analysis is admirably discussed in one of the two principal articles in the autumn number of the *Interchemical Review*. Those interested in dyes, textiles, and history will find interesting reading in the other principal article, "Colors for textiles: Ancient and modern."

● The position that the industrial research laboratory occupies in a large plant is discussed in some detail in the *Lamp* for December. Another article on natural gas and its increasing importance and others on jet propulsion and the gas turbine make this a valuable number, quite aside from the beautiful collection of color prints of scenes in the production, refining, and utilization of oil.

● Arthur D. Little, Inc. (Cambridge, Massachusetts), has recently issued a bulletin entitled, "Some Information about Arthur D. Little, Inc.," which is a valuable account of the general methods of industrial research and, with good illustrations, shows many interesting things about the activities of such an organization. It could be an inspiration to young, aspiring chemists hoping to go into this productive field.

● The following is from the January *Industrial Bulletin* of Arthur D. Little, Inc.:

MORE NYLONS

Nylons are not just hard-to-get stockings but a family of related plastics having imposing industrial possibilities. The patent literature records more than 300 uses covering a bewildering variety of products.

Industrially, nylon is a valuable plastic because of its extreme toughness, good insulating properties in electrical equipment, high softening and melting temperatures, low flammability, and resistance to common solvents. Nylon plastics may be safely sterilized by steam, a property possessed by few heat-softening resins.

Industrial products made by rapid and inexpensive injection molding of nylon include such varied items as slide fasteners, immune to dry cleaning solvents and ironing temperatures, and spools having a wall thickness of only a hundredth of an inch, useful for winding electrical coils for aircraft instruments. Nylon molding powder now sells for about $1.60 a pound, several times the price of the cheapest plastics, but not too much for special applications.

The nylon molecule may be likened to a long chain of about 100 links. Within limits, different materials can be used for the links and the materials can be combined differently. Thus nylon may be tailored to meet many specific requirements of stretch, tensile strength, flexibility, and impact strength. Nylon can also be tough but not hard in one form, the amorphous, and hard but less pliable in another form, the crystalline.

Nylon's toughness and flexibility suit it well as a leather substitute, although the paucity of solvents for it makes it difficult to apply to a cloth backing. Its high resistance to temperature, flexing, and electrical effects, makes it useful for some rubber applications, such as wire insulation. Its high abrasion resistance makes possible superior "silk" screens for printing of pigments on ceramics. In the form of coarse single fibers called monofils, nylon is in many instances superior to natural products for such articles as fishing leaders, racket strings, brush bristles, and tire cord.

NONFERROUS METALS AID IN STEEL'S USE

JACOB LEVIN

Department of Commerce, Washington, D. C.

LEAVE a piece of ordinary, bare steel—say a sheet—out in the open for a few weeks or even for a few days. Let the air, the wind, and the rain get to it, and what happens? It rusts—a corrosive film develops, which not only discolors the metal but actually eats it away. Now take an exactly similar sheet. Give it a coating of metallic zinc, or tin, or any of a number of other nonferrous metals and their alloys. Subject it to the same conditions as you did the other sheet, and the worst you will get is a tarnish or patina on the coating. The steel itself will remain intact.

This basic fact—that ordinary steel corrodes under conditions which will not affect its sister metals of the nonferrous group and, under the most adverse conditions, will corrode more quickly—has been of great significance to the development of the metal industries. Without the protection that these nonferrous metals afford, steel could not find employment in a multitude of its most common forms. The qualities of steel that make it so important in so many everyday uses—its cheapness, it strength, and its versatility—would be largely wasted. In return, the need of steel for the protection, because of its own relatively poor resistance to corrosion, has been one of the most important factors in the use and development of some of the nonferrous metals, notably tin and zinc.

Nonferrous metallic coatings are by no means the only kinds used to protect steel from corrosion. A variety of other types of coatings are in daily use and are well known—porcelain enamel, paint, lacquer, rubber, asphalt, to name some of them. Yet the use of metal on metal is not only of great importance from the standpoint of tonnage, but also of interest from the standpoint of the numberless products of almost infinite variety that have been made through the combination.

The history of the use of tin and zinc and any of the other materials as coatings has been one of a continual search for the most economical coating that will best satisfy the requirements of protection, utility, and appearance, and still preserve the strength and cost advantages of the base steel. Corrosion is an expensive item in our economy, estimated to run into the hundreds of millions of dollars each year. To combat it, the laboratories of individual companies and scientific organizations all over the country are continuously in quest of better methods.

A notable example of cooperative effort toward the solution of some of the problems is the series of tests being currently conducted at Kure Beach, on the North Carolina coast, by three of the leading companies in the metals field, in conjunction with some 200 other companies and some of the technical societies. Here, under natural conditions, tests are being made on the effect of sea air and water on iron and steel and the nonferrous metals.

The nature of the coating—as to thickness and type of metal—varies with the forces of corrosion at work. At inland locations the atmosphere naturally varies from that on the seacoast, and the effects of each on steel necessitates either different kinds of coatings or different thicknesses. Similarly, the air over an industrial city with its deleterious fumes is quite different from that above the hamlets and farms scattered throughout the country. The use of chemicals has a more harmful effect on the metal linings of containers and on machinery than does fresh water; and even water varies in its mineral components and its action on metals.

The various methods of applying metallic coatings are almost as numerous as the kinds of metals used. Besides tin and zinc, the metals that are employed more or less extensively include cadmium, nickel, copper, chromium, aluminum, cobalt, lead, various alloys, and in special cases, silver, gold, and the platinum-group metals. The methods used, varying with the type of metal and the end results desired, are hot-dipping, electrodeposition, heating in metallic dust, spraying, and cladding.

In the prewar years about two-fifths of all the tin consumed in this country went into the manufacture of tin plate, which in turn constituted from seven to eight per cent of the total finished products of the steel mills. Two effects of the war—the prior needs of steel for direct war uses and the loss of tin sources in the Far East to the Japanese—prevented a continuation of the prewar high rate of consumption.

This significant role of tin derives from its special qualities, particularly its corrosion resistance and nontoxicity. In the manufacture of tin plate, used chiefly for metal containers (mostly the common tin can for food preservation), it is applied in thin coats to both sides of light-gage sheets of steel.

When used in tin cans for food containers its nontoxicity comes into play on the inside of the can. Tin is highly resistant to a wide range of food acids, the attack of which is lessened or en-

USE OF TIN AND COATING STEEL

[In short tons]

Item and usage	*1943*	*1942*	*1941*	*1940*	*1939*	*1938*	*1937*	*1936*	*1935*
Tin used in tin plate	24,333	31,945	50,236	43,315	40,768	26,370	43,927	37,800	30,565
Per cent of total tin used	27.0	33.3	33.3	39.8	44.2	39.4	43.5	40.6	38.3
Tin plate produced for sale	2,104,718	2,657,950	3,565,885	2,689,856	2,561,451	1,618,317	2,758,295	2,316,986	1,856,908
Per cent of total finished products for sale	3.4	4.4	5.8	5.9	7.3	7.6	7.2	7.6	8.4
Zinc used in galvanizing	253,000	247,491	350,854	287,000	275,000	198,000	256,000	242,000	195,000
Per cent of total zinc used	31.8	34.0	42.4	39.9	43.9	47.0	42.0	41.6	41.2
Galvanized sheets, pipe, barbed wire, and formed products	1,806,033	1,788,087	2,804,183	2,707,466	2,503,345	1,740,725	2,259,510	2,154,948	1,696,057
Per cent of total hot-rolled products	2.9	2.9	4.5	5.6	6.4	7.4	5.5	5.7	6.3

Sources: U. S. Bureau of Mines, American Bureau of Metal Statistics, and American Iron and Steel Institute.

tirely removed by the exclusion of oxygen from the inside of the can, as in vacuum packing or hermetic sealing. On the outside of the can the tinned surface is more resistant to atmospheric corrosion than the steel base, although there is a rapid oxidation that dulls, to some extent, the shiny appearance of the can. The combination of the two metals, embodying the best qualities, results in a product which is cheap, strong, ductile, easily soldered, and corrosion resistant.

The application of tin coatings to (wrought) iron plates dates back to the thirteenth century, when it had its beginnings in Bohemia. From there the practice extended into Saxony by the early part of the seventeenth century. About 100 years later, in 1720, the tin-plate industry had become an established one in England, particularly in Wales, with its tin mines and abundant water power.

At various milestones along the way came improvements in the processes of manufacture—the rolling of sheets replaced hammering from bars; the pickling machine, for cleaning the surface of the plate, and the annealing pot, for smoothing it, were invented; the coating of the plate became a mechanized process; and progress was made in the art of canning.

One of the most significant developments in the history of tin-plate making began in 1875 with the substitution of steel for wrought iron. The latter metal had been made in two ways: with charcoal alone as a fuel, and with a mixture of charcoal and coke. The terms, charcoal and coke tin plate, derived from the two methods, respectively, have come down into the present trade but without the original meanings.

Charcoal today refers to a tin plate with a comparatively heavy or thick coating of tin, while coke refers to a lighter or thinner coating. In both cases the steel sheet base is made in the same way. Because of the satisfactory performance of the thinner coating, charcoal tin plate has almost passed into oblivion. A third type, known as silver tin, has a heavy coating of tin and a dull surface, the base plate having been mechanically roughened. This class is likewise unimportant.

About 15 years after the introduction of steel as the base metal the tin-plate industry had its real beginning in the United States. Abortive attempts had been made to establish production before this time, but it was not until the passage of the McKinley Tariff Act of 1890 that the industry was able to get a start. That act provided protection to an infant industry through a tariff of 2.2 cents per pound on imported tin plate.

Technological improvements have continued to play an important part in the development of the industry. Within the last two decades two factors have been of far-reaching importance and effect. The first of these was in the manufacture of the steel-sheet base, the other in the application of the tin coating. In 1929 came the first commercial manufacture of cold-reduced strip in tin-plate gages, as opposed to hot-rolled. Within 15 years this phase of manufacture has been completely revolutionized, and today the production of final hot-rolled tin plate is of a negligible amount. The changeover has resulted in a superior product, one that is more ductile, thinner, and of more uniform gage, permitting a more uniform tin coating.

The second change, the development of electrolytic tinning as opposed to hot dipping, was given impetus by the war, insofar as it meant the possibility of a thinner coating and a consequent saving of tin. The commercial production of electrolytic tin plate began in 1936, but was not significant enough before 1942 to warrant a separate statistical record. Since then it has grown in importance, with the increasing installation of electrolytic lines.

While in 1942 the production of electrolytic tin (and terne) plate amounted to only 82,426 short tons and constituted only three per cent of the total, the amount had risen to slightly more than 600,000 tons in 1944, and was 23 per cent of the total. The output during 1945 will, on the basis of production during the first 8 months, reach new highs both tonnagewise and percentagewise.

There are several advantages to the electrolytic method of coating. Not only thinner coatings but even thicker coatings can be obtained than with the hot-dipping process. Coatings as thin as a few millionths of an inch have been achieved, although the thickness, of whatever type of deposition, usually runs from 0.0001 to 0.0002 inch. Thicknesses between 0.0005 and 0.001 inch obtained by the hot-dipping method require repeated dipping and exact temperature control. By the electrolytic method coatings up to 0.125 inch have been applied for special purposes. On the other hand, electroplated tin surfaces are dull and require polishing or other treatment for brightness.

Tin is also applied to steel in other forms than as a constituent of tin plate. By both the hot-dip and the electrolytic methods it is applied to fabricated articles of various types, ranging from steel pins to food-processing and dairy equipment. An advantage of electroplating, the relatively low temperatures at which deposition is brought about, protects soft-soldered joints. There is some tinning of steel wire, but only on a very small scale.

A third method of depositing a tin coat—metallizing, or spraying—is finding increasing application with various other metals as well. This consists of feeding the tin in the form of a wire through special apparatus at a regular pace, whereby the tin is melted and projected in minute particles onto the surface to be covered. This method has value in applying coatings to fabricated articles of complicated shape and large dimensions. (The spraying process is also used with various metals in the repair and building up of worn parts. While the purpose in such uses is not for corrosion resistance, the methods of application are essentially the same.)

A tin-lead alloy is applied to a steel base in the manufacture of terne plate. In this form the tin serves as a bond between the steel and the lead, when the latter can be used without harmful effect. Tin does not form a major part of the alloy, ranging from 12 to 50 per cent of the composition. In the most widely used combination the ratio is 80–20 in favor of lead. Terne plate is made in two general size types—short terne, which is comparable in size to tin plate, and long terne, which is of much larger dimensions. Terne plate is used principally in roofing. Other applications are in the manufacture of automobile gasoline tanks, petroleum containers (drums and cans), and metal furniture and cabinets.

When zinc and steel (or iron) are in contact, corroding agents will attack the zinc in preference to the other metal. Because of this fact and the fact that zinc can "take it," it has found its single principal outlet in the coating of iron and steel. Through its ability to protect the base metal, zinc has enhanced those

values of steel which result from its advantages of strength and cheapness. This protection is so effective that even in the case of a small exposed area on the base metal the attack of the corrosive elements will first be directed to the zinc coating.

Much galvanizing is done outside the steel mill, for the protection of varied fabricated products. While the recorded consumption of zinc in galvanizing includes that used in all applications, the statistics for coated products, which exclude plain wire as well as fabricated products, understate the facts.

Whether applied to sheets, or pipe, or wire, or to a multitude of manufactured articles, zinc affords protection in uses too numerous to list completely. Galvanized sheets, the most important shape, are used in roofing and sidings for all types of structures, often in corrugated form. An outstanding use during the late war was in the construction of the Quonset hut, which became a byword along with the bazooka, the B-29, and K-rations, and which has now passed over into the postwar world of civilian construction.

The galvanized pail is a common household item. Galvanized pipe is used widely in both domestic and industrial installations. Galvanized wire, barbed and plain and in the form of fence, is used extensively on farms, by railroads, and in construction. Throughout many industries zinc-covered products are integral parts of equipment and buildings. In some of its uses the zinc coating is supplemented, for the sake of appearance and added protection, by paint.

The application of zinc to the base metal requiring protection is made in four different ways. In all of them improvements are continuously being made or are under study, not only in the actual process of application but also in the preparation of the base metal for optimum results. The most common method used, especially on flat steel, is hot dipping, in which the article, after being cleaned, is immersed in molten zinc. Here the zinc coat affords a twofold protection. The contact of the steel with the zinc first forms a solid alloy of the two metals on the surface of the steel. As the process continues a layer of zinc is deposited over the alloy, and the net result is an article of steel doubly protected. The life of the galvanized product depends directly on the thickness of the zinc coating, which varies according to type of product and the protection required.

In the electroplating process zinc is applied to strip and wire, as well as to various fabricated articles, onto which the coat is laid in metal-finishing shops. As in other phases of protective coating, improvements continue to be made in this process. Concurrently with the development of continuous electrodeposition of tin on strip steel, in the manufacture of tin plate, have come similar advancements in zinc plating.

In metallizing, or spraying, the method is similar to that described above for tin. In the field of protective coating this process finds its principal use in connection with zinc. It is used for coating objects too large for hot-dipping, such as bridges, tanks, and ships. On the other hand, for many small finished parts, such as nuts, screws, and bolts, a fourth method—sherardizing—is used. In this process the articles are packed in a revolving drum with fine zinc dust, and heated to a temperature somewhat below the melting point of zinc. The resulting coating is a thin one, similar in form to that obtained by the hot-dipping method. In a variation of this process, called hot-galvanizing, flaked zinc is used instead of dust.

For special uses other metallic coatings are applied, employing similar principles to that used in sherardizing—aluminum, by calorizing, and silicon, by ihrigizing.

While various coatings besides zinc and tin are deposited by electroplating methods, not all of them are formed primarily as protection against corrosion. In some cases decorative purposes may be the prime consideration; in others, it may be resistance to wear. Whatever the end sought, its attainment requires a coating possessing, in addition to a satisfactory appearance or hardness, the ability to withstand corrosion. The one cannot be achieved or maintained without the other. The coatings thus used therefore play a dual role.

In one method, which has been developed in recent years, a multiple coating is applied to provide a corrosion-resistant cover. A thin coating of nickel is first applied, and over this a thin coating of zinc, or tin, or other metal or alloy.

Cadmium, a companion metal to zinc, is especially effective against the corrosive attacks of sea water and air. Because of this quality it found important use during the war in the protection of military equipment. In peacetime uses its uniform, attractive color is an asset, although its general application is restricted by its relative scarcity and its cost. In 1944 the total new supply for all uses was less than 5000 short tons.

Nickel is widely used in peacetime in electroplating, although that is not its principal use. Frequently it is covered with a surface flash of chromium, in order to secure freedom from tarnish. In some cases, as in automobile trimmings, it is used in conjunction with both chromium and copper, to give the desired bond, appearance, strength, and corrosion resistance.

Chromium, used for decorative reasons as well as to give a protective coating, is especially valuable for its nontarnishable finish, its hardness, and its resistance to wear.

Other metals used in electroplating, besides those already mentioned, include the copper-base alloys—brass and bronze—cobalt, lead, silver, gold, tungsten, and other alloys.

Another method of protection, which takes special advantage of steel's strength and relative cheapness, finds widespread use in industry. This is the cladding of corrosion-resistant metal on a steel base, usually performed by rolling the two metals, in proper proportions, upon each other. This operation forms a bond between the steel base and the covering metal. The thickness of the corrosion-resistant metal depends on the proposed application of the finished article and upon the nature of the metal. In the case of thick products, of plate dimensions, the coat may vary from two per cent to as much as 20 per cent of the thickness of the plate.

Among the cladding metals used are nickel, one of the nickel alloys, either monel or inconel, copper, aluminum, and silver. (Stainless steel, strictly speaking an alloy of ferrous and nonferrous metals, is also applied in some cases.) While the nonferrous metal alone could be used without the steel backing, the savings through the use of steel warrant the cladding process. The process of rolling clad steels is as exacting as any phase of steel production or fabrication. Care must be taken to avoid contamination of the cladding metal with particles of iron. This is important because of the diverse uses to which the finished products are often put, as in the complicated machinery and equipment of a variety of industries in the chemical, food-processing, drug, petroleum, paper, and other fields.

Copper-clad steel combines the strength of the steel with the high conductivity and corrosion resistance of the copper, and is made in flat steel as well as in wire form.

The advances made in the techniques of protective coating during the war and those being continuously made through the combined efforts of industry and government in scientific research will accrue to the advantages of our postwar world. The advantages which the use of corrosion-resistant materials bring may be measured in dollars and cents, not only for the manufacturer but also for the consumer. Rust eats as deeply and as harmfully into profits and the household budget as into physical metal.

Along with the progress of metallurgical art and practice which has developed newer and better ways of protecting vulnerable steel through lighter, better, and cheaper coatings, have come other factors which will lead to some conservation of metals. These have included the developments of substitutes notably in the packaging field. The shortage of tin was not an unmixed curse. It hastened, among other things, the advancement of plastic, glass, paper, and other containers for food and a host of other products. Tin plate will undoubtedly regain much of its forcedly lost ground, because of its qualities of cheapness and lightness. How much it will regain remains to be seen, as other factors, such as consumer preference, become effective.

At least, in the long run, we may hope that all developments which tend towards the saving of natural resources will push back farther into the future the often-predicted day of a shortage of steel, and zinc, and copper, and lead in this country.—Reprinted from *Domestic Commerce* (December, 1945).

Vicente Marcano (1848–1891)

A Pioneer Chemist of Venezuela

CONRADO F. ASENJO

Department of Chemistry, School of Tropical Medicine of the University of Puerto Rico, Under the Auspices of Columbia University, San Juan, Puerto Rico

VINCENTE MARCANO

VICENTE Marcano is probably best known outside his native country, Venezuela, for his discovery of the proteolytic enzyme of the pineapple, bromelin. Though none the less valuable, his other contributions to science are neither as widely known nor as appreciated as they deserve to be.

Marcano was born in Caracas on October 27, 1848. At the age of seven he completed his primary education and entered "Colegio Roscio," where he studied the prescribed classical courses in Latin, philosophy, and mathematics for five years. Shortly before he terminated these studies, the *Universidad Nacional* of Caracas was closed in 1860 because of a long and cruel civil war. Young Marcano had to wait until 1864 to take the official examinations and to receive the degree of *Bachiller*.

In order that his son might benefit from a broader education abroad, Marcano's father sent him to Paris to study for a career. After two years in a preparatory school in the French capital, Marcano entered, in the summer of 1866, the Central School of Arts and Manufactures from which he was graduated three years later with the degree of industrial engineer. During this time Marcano developed a special liking for chemistry, majoring in this subject under the direction of La Salle and Cohours.

At this time he met Adolphe Wurtz, then Professor of Chemistry at the *Ecole de Médecine*, and was afforded the rare privilege of admission as a part-time student to the latter's laboratory. It was there that Marcano spent all his spare time during the last two years of his engineering studies. Wurtz, in turn, became very fond of the young and enthusiastic South American, and a warm friendship, which lasted a lifetime, developed between the teacher and student. Marcano's deep gratitude toward this eminent French chemist is movingly expressed in a biography in Spanish,[1] written shortly after Wurtz's death in 1884.

It was during this period of study that Marcano became interested both in the practical as well as the theoretical aspects of chemistry. In the congenial company of some of Wurtz's younger collaborators—Naquet, Scalet, Gautier, and Grinaux—he acquired a thorough grounding in the newer concepts of the atomic theory. Several years later, in 1881, Marcano wrote a book on theoretical chemistry,[2] based on the atomic theory. In a short introduction to the book he explained how he had conceived the general plan of this treatise during that interval of intense intellectual interchange in the company of Wurtz and his associates. This was one of Marcano's most important contributions to chemical education, and for a long time the book was the only up-to-date text on theoretical chemistry in the Spanish language available in Venezuela. Its clearness of exposition and its precise style contributed greatly to stimulate interest in the study of chemistry in that country.

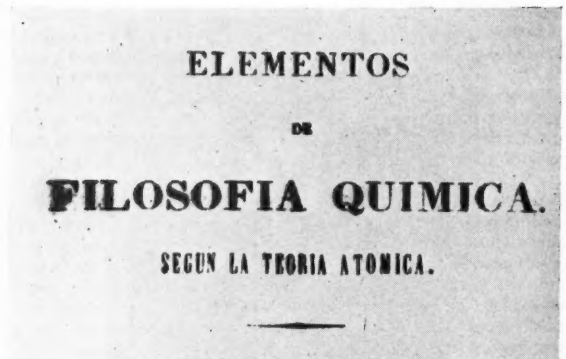
Marcano returned to Venezuela in 1869, and soon after was appointed professor of the newly created chair of industrial chemistry at the *Universidad Nacional*, a position for which he was well prepared. He undertook this arduous task with his usual energy and enthusiasm, and in a short time had not only organized a course of lectures but had also set up a laboratory from the meager equipment at hand. This strenuous but pleasant work did not last very long, however. Political unrest closed the doors of the *Universidad Nacional*, and Marcano found himself without work.

Looking for wider horizons, Marcano left for France in June, 1870, and settled again in Wurtz's laboratory. While there, he commenced an investigation on the composition and nutritive value of a large number of Venezuelan root-crops, but his scientific endeavors soon came to an end again because of the Franco-Prussian War. During the siege of Paris, Marcano served as a pharmacist and minor surgeon in the fighting lines, for which services the French Republic awarded him a medal.

When hostilities finally ceased, Marcano went to England for a few months. He had planned to accept a

[1] Marcano, V., "Adolphe Wurtz," Imprenta Editorial, Caracas, 1884.

[2] Marcano, V., "Elementos de Filosofía Química Según la Teoría Atómica," Caracas, 1881.



ELEMENTOS

DE

FILOSOFIA QUIMICA.

SEGUN LA TEORIA ATOMICA.

POR

VICENTE MARCANO.

Antiguo alumno de la ESCUELA CENTRAL DE ARTES Y MANUFACTURAS de Paris -Miembro de la *Sociedad Química* de Paris, etc. etc.

PRECEDIDO DE UNA CARTA

DE

A. NAQUET.

Profesor Agregado de la Facultad de Medicina de Paris. Diputado á La Asamblea Nacional de Francia etc, etc

CARÁCAS

1881.

TITLE PAGE OF "ELEMENTS OF CHEMICAL PHILOSOPHY" BY VICENTE MARCANO

position as "preparateur," which Wurtz had offered him in Paris, but for the third time in a little over a year, war and political unrest prevented him from realizing his desire to consecrate himself to the study of the sciences. On returning to Paris, he found the city in the anarchic throes of the Commune. More peaceful surroundings beckoned, so he left Paris and returned to his native Venezuela in the summer of 1871.

While Marcano was in Paris, he bought the equipment necessary for a chemical laboratory, which he established as soon as he was settled in Caracas. According to his announcement, this laboratory was to serve the dual purpose of a teaching and a research center. Marcano also tried, with little success, to attract the attention of physicians, pharmacists, and manufacturers to the facilities which the laboratory offered to their respective professions, little realizing in his enthusiasm how narrow was the scientific outlook that prevailed in the Venezuela of the seventies. With but few exceptions, his services were not requested, and his efforts to create a teaching and research center were received by the general public more or less apathetically. Notwithstanding, Marcano did some of his best work in this modest establishment, probably the first of its kind in Venezuela. Many years later, in 1890, due to Marcano's efforts, a municipal laboratory was established in Caracas for the inspection of foods and household articles.

Marcano visited Paris three more times during the remaining years of his life—in 1878, in 1883, and lastly, in 1888. These visits to the French capital were always extremely stimulating and offered him the opportunity of renewing old acquaintances as well as making new ones; at the same time he could avail himself of important information which, otherwise, would never have reached him in Venezuela.

Marcano's chemical investigations may be roughly divided into three groups: those dealing with the composition and physiology of tropical plants; those dealing with the composition of minerals, waters, soils, and natural fertilizers; and, lastly, those dealing with fermentation and ferments, as our present enzymes were known in those days. In 1883 Wurtz read before the Academy of Science of Paris a paper[3] by Marcano, the first one to be presented by him before this famous institution of learning. Wurtz wrote to his pupil and protegé the following letter describing the occasion and commenting upon the latter's findings:

Paris
August 14, 1882

My dear Marcano:

Yesterday I read before the Academy your interesting note. It will be published in the next issue of the *Comptes Rendus*. A microörganism being directly responsible for the alcoholic fermentation of cornstarch seems to me a very interesting fact.

But have you established definitely that this fermentation is not produced by inversion or by hydrolysis due to a diastase? What happens to the starch when it is reabsorbed during germination? These are questions which I take the liberty of suggesting to you at the same time that I congratulate you sincerely for the way you have studied and presented the facts you have discovered. Now it remains for you to continue these studies.[4]

With regard to me, it will always be a pleasure to be your interpreter before the Academy. Accept my expression of sincere affection.

A. WURTZ

After this initial paper many others followed, all read to the academicians by Wurtz, Berthelot, Duchartre, Schloesing, or Müntz,[5] and, on one occasion, by Marcano himself. This happened during the summer of 1883, when he brought before the consideration of the Academy his theory on panification,[6,7] a subject in

[3] "Fermentation de la fécule (présence d'un vibrion dans la graine de mais qui germe et dans la tige de cette plante)," *Compt. rend.*, **95**, 345–47 (1882).

[4] Marcano followed Wurtz's advice and continued these studies. A few months later he sent a second communication to the Academy, entitled "Fermentation directe de la fécule (mecanisme de cetté métamorphose)," which appeared in the *Compt. rend.*, **95**, 856 (1882).

[5] Aquiles Müntz was professor at the Agronomical Institute of Paris and Marcano's inseparable collaborator and friend since 1878, when they met at Bossingault's laboratory in the *Conservatoire des Arts et Métiers*.

[6] "Sur la panification," *Compt. rend.*, **96**, 1733–34 (1883).

[7] "Sur la formation des quantités notables d'alcohol dans la fermentation panarie," *ibid.*, **97**, 1070–71 (1883).

which he was deeply interested and on which he had worked for many years.

Marcano believed that the underlying mechanism of breadmaking was due, at least in tropical climates, to a bacterium which produced ferments that changed not only gluten into peptone but also starch into dextrin and glucose and, if given sufficient time, even into alcohol. He also studied the fermentation mechanism of *yaraque*,[8] a spirituous liquor prepared by the Orinoco Indians from the *casabe* (*Manihot utilisima* L.). Marcano showed that the organism responsible for this fermentation was a fungus, the micellium of which secreted a diastase that degradated the starches to dextrins and sugars, while its spores secreted a second enzyme that converted glucose into alcohol. He conducted similar studies on the *chicha*, a liquor obtained from the fermentation of corn, and also on the fermentation of the juices of such tropical fruits as the sugar cane, mango, banana, pineapple, sapote, guaba, and papaya.

Marcano's interest in enzymes also included the proteolytic ferments secreted by microorganisms.[9,10] He used these ferments for the preparation of commercial peptone from meat and so successful was his procedure that he was offered the directorship of a large peptone-producing plant in Argentina, a position which he declined.

His discovery of a papain-like enzyme in the pineapple was accomplished just a few months before his untimely death on July 17, 1891. Marcano named this enzyme "bromelin," as the pineapple is scientifically known as *Bromelia annana* (L). As far as we have been able to discover, he did not live to publish the results of this last investigation, the one that made him best known outside his native country; however, Marcano seems to have personally communicated his findings to other scientists. In 1891 the late Professor R. H. Chittenden of Yale University published a long paper[11] dealing with bromelin, wherein he mentioned in a footnote that this enzyme had been discovered a year previously by the Venezuelan chemist, Vicente Marcano, who had recently died. In many American and European journals of that period, short news notes appeared stating that a new papain-like enzyme had been discovered in the pineapple by the Venezuelan, Vicente Marcano.

In that same year (1891), two enterprising South Americans in the city of Detroit established a concern under the name of Mosquera, Julia Food Company,[12] for the manufacture of a food predigestor containing bromelin as its principal constituent. This concern was active for several years and later became a subsidiary of Parke, Davis and Company of Detroit

Marcano's deep interest in the development and improvement of scientific agriculture in his country led him, in collaboration with Müntz,[13–16] to study the nitrified soils and guano deposits of Venezuela. During the preliminary part of this work he made many field trips throughout the Republic and not only collected a large number of soil samples but also made a survey of the mineral resources of the country, which last information he incorporated into a mineral map of Venezuela. He exhibited this map at the Paris Exposition of 1878, and received favorable comments, since the map showed for the first time, in an integrated form, the vast and diversified mineral wealth of that Republic. It should be pointed out here that Marcano practiced the profession of mining engineer and that his services were in great demand in Venezuela.

In 1831 Avequin announced the presence of mannite in the seed of the avocado pear. In collaboration with Müntz, Marcano repeated Avequin's work and found that the substance, identified as mannite by that famous French chemist, was no such substance but an isomer that they named perseite ($C_{12}H_{14}O_6$).[17] They even went further and found that perseite is not only present in the seed of the avocado but also in its pericarp and leaves.

As Venezuela produced a large crop of bananas, a fruit which at that time was not as popular in the foreign market as it is today, it was natural for Marcano to become interested in it. One of the first complete analyses of the banana was performed by Marcano and Müntz.[18] They also studied the possible uses of the fruit.

These were only some of the many investigations that Marcano performed alone or in collaboration with Müntz on the composition of tropical plants.

Another science that attracted Marcano's attention was ethnology. He became an assiduous worker in this field and organized many expeditions to remote localities to investigate the pre-Columbian civilizations of Venezuela. He published several papers on ethnological subjects, one of the most important of which was a chemical analysis of the metallic utensils used by the pre-Columbian inhabitants of the Orinoco Region.[19]

Together with Dr. Antonio Ramela and Dr. Adolfo Frydensberg, Jr., Marcano founded *La Unión Médica* in 1881; this was a scientific journal devoted to medicine and allied sciences. *La Unión Médica* published in Spanish much of Marcano's work, the same inves-

[8] "Sur le *yaraque*, boisson fermentée des tribus sauvages du haut Orénoque," *ibid.*, **107**, 743–45 (1888).

[9] "Sur la fermentation peptonique," *ibid.*, **99**, 811–13 (1884).

[10] "Sur la fermentation peptonique de la viande," *ibid.*, **107**, 117–19 (1888).

[11] CHITTENDEN, R. H., *Tr. Conn. Acad. Sci.*, **8**, 281 (1891).

[12] According to the Detroit Directory, this concern was incorporated on April 8, 1890, with a capital of $50,000. One of the members, Mr. J. A. Mosquera, had been a former pupil of Marcano.

[13] "Sur la formation de terres nitrées dans les régions tropicales," *Compt. rend.*, **103**, 65–68 (1886).

[14] "Sur la formation de terres nitrées," *ibid.*, **108**, 900–02 (1889).

[15] "Sur la proportion de nitrates contenus dans les pluies des régions tropicales," *ibid.*, **108**, 749–50 (1889).

[16] "L'ammoniaque dans l'atmosphere et dans las pluies des régions tropicales," *ibid.*, **113**, 779–81 (1891).

[17] "Sur la perseite (matiere analogue a la manite)," *ibid.*, **99**, 38–40 (1884).

[18] "Sur la composition de la banane et sur des essais d'utilization de ce fruit," *Ann. chim. phys.*, **T.XVII**, 568–74 (1879).

[19] "Sur la métallurgie précolombienne au Venezuela," *Compt. rend.*, **110**, 711–13 (1890).

tigations that he later sent to France and which appeared in the *Comptes Rendus* and other French journals. Marcano's interest in scientific publications was not restricted to those exclusively for the initiated; on the contrary, he was a prolific author of popular scientific articles which appeared in Venezuela's daily press. His greatest ambition was to make his countrymen conscious of the importance of the scientific method in the daily approach to living.

As he was quite gifted as a writer, Marcano published many purely literary articles as well as a large number of short stories for children. These last are still well known in Venezuela. He later gathered many of his literary essays into a small volume entitled, "Páginas Sueltas" ("Loose Leaves"), which was printed in Paris in 1878.[20]

The last years of Marcano's life were devoted almost exclusively to organizing institutions for the teaching of scientific agriculture. After listening for many years to Marcano's theories of the benefits to be derived from a rational and scientific cultivation of the soil, the government of Venezuela at last provided him with the necessary funds for the establishment of an Agronomical Institute in Caracas. At about the same time the government of the State of Carabobo became agronomically conscious, and a similar institution was planned there. As the leader and prophet in this field, Marcano was asked to organize both institutions, a task which he undertook with his characteristic zeal.

One of his first preoccupations after entering upon this important undertaking, was to prepare a text that would convey to students of agronomy his ideas on the scientific methods to be used in the tropics. Marcano completed the manuscript of this important work a few weeks before his death in 1891. His book was printed posthumously under the title, "Essays in Tropical Agriculture."[21]

At the time of his death, Marcano was a prominent member of the College of Engineers of Caracas, of the Chemical Society of Paris, and of the National Society for the Development of Industry of France. He was buried with honors in Valencia, capital of the State of Carabobo, in Venezuela.

Material for this paper has been derived principally from a biography of Vicente Marcano, by his brother, Dr. Gaspar Marcano ("Biografía de Vicente Marcano (1848–1891)," Imprenta Montorier, Paris, **1893).** I am particularly indebted to Dr. Félix M. Beaujon, President of the "Sociedad Venezolana de Química," for providing me with a typewritten copy of this now extremely rare book.

[20] "Páginas Sueltas," Imprimerie de V. Fillon et Cie, Paris, **1878.**

[21] "Essais d'agronomie tropicale," *Ann. sci. agron. francaise et étrangère,* Uitieme Annee, **T.I,** 119–52 (1891).

Note on van der Waals Reduced Equation of State

CHARLES A. STEVENSON

Stokely Foods, Inc., Indianapolis, Indiana

THE van der Waals equation

$$p = \frac{RT}{V - b} - \frac{a}{V^2}$$

leads to the reduced equation of state

$$(\alpha + 3/\beta^2)\,(\beta - 1/3) = 8/3\,\gamma$$

where

$$\alpha = p/p_c,\ \beta = V/V_c,\ \gamma = T/T_c$$

The subscript c refers to the critical state.

The reduced variables of state α, β, γ are pure numbers and may assume any positive value. It is a matter of interest to inquire as to the conditions in which these variables assume coincident values. The condition that $\alpha = \beta = \gamma = k$ as given by the reduced equation of state is

$$(k + 3/k^2)\,(k - 1/3) = 8/3\,k$$

or

$$f(k) \equiv k^4 - 3k^3 + 3k - 1 = 0$$

This equation has four real roots, one being negative and three being positive. Only the positive roots have physical significance. By inspection one root of $f(k) = 0$ is seen to be unity. The other two positive roots are found to be 0.382 and 2.618. Thus the roots in question are

$$k_1 = 0.382$$
$$k_2 = 1$$
$$k_3 = 2.618$$

We note immediately that $k_2 = 1$ defines the critical state. Note also that

$$\frac{k_2}{k_1} = \frac{k_3}{k_2}$$

that is, these roots form a geometric progression.

Each of these three roots satisfies the original van der Waals equation, and the three states of a van der Waals substance defined by k_1, k_2, k_3 lie on the appropriate isotherm.

Therefore, the reduced equation of state connects the critical state defined by $k_2 = 1$ with two other unique states—namely, a certain liquid state defined by $k_1 = 0.382$ and a certain gaseous state defined by $k_3 = 2.618$. All three of these states are characterized by the condition that $\alpha = \beta = \gamma$.

Science Seminars

SISTER M. IGNATIA, I.H.M.

Marygrove College, Detroit, Michigan

ONE of the major complaints of those who hire young college graduates who have majored in the physical sciences is that they are not able to express their ideas with clarity![1] They are well trained in laboratory techniques, but they are not able to write a research paper or to contribute to the company seminar. Their interests are not sufficiently broad. They know little of the philosophy of science, of the fundamental social problems related to their field, or of the relationships that tie the physical to the social sciences.

OBJECTIVES

The "Seminar in Fundamental Relations" required of all juniors and seniors at Marygrove College for the past nine years is a device, not sufficiently well known, which at least partially eliminates these complaints. According to the college bulletin for 1945–46, the seminar is "a four-semester cycle of courses in which each department combines successively with one or more departments for the investigation and discussion of common problems. Objectives: experience in research; development of power of formal and informal discussion. The subject for each semester is determined in the departments that are working together. One hour a week is devoted to a departmental meeting; one hour, to an interdepartmental meeting." A former edition (1942) of the same college bulletin states that in this course the student "applies herself specifically to a study of relationships. She sees her own field as an integrated part of the bigger thing that is human life. . . . She finds out for herself the practical philosophic, moral, and religious implications of apparently compartmented arts and sciences."

PLANNING BY DIRECTORS

To secure this integration, training in research, and development of power in discussion, the seminar is built on the "problem" idea. A general problem is selected before the beginning of a new semester by the faculty directors, a group composed of one member from each of the departments working together that particular semester. The general problem is then broken down into a series of more specific ones, which in turn are subdivided into smaller problems, one for each student involved in the course. The problem must allow for the formation of an opinion as the basis of discussion and must be real in the sense that the students do not know the answers before they start their research. Related problems are grouped together and a logical sequence worked out by the faculty directors as the semester's program of approximately thirteen weekly seminars.

PREPARATION OF THE PAPERS

At the beginning of the semester this sequence of problems is presented to the students. Each student chooses the problem she prefers and in due time locates and reads as much material on it as possible. She gives it careful consideration, talks it over with her seminar director, reaches a decision, and formulates a proposition. She then writes a logical outline in proof of her proposition. At least two weeks before her paper is to be given, she presents this outline together with her bibliography and notes to the seminar director for approval. When the outline is approved (possibly only after revision) the student writes a paper of approximately eight hundred words, submits it at least a week before the paper is to be given to the seminar director, and rewrites it, if necessary, in accordance with the suggestions of the latter. Then she prepares to give the paper and to answer anticipated questions and objections.

BACKGROUND READING

To acquire the knowledge necessary for comprehension of the problems under discussion, and as the basis for their own contribution, the students spend four hours each week reading and taking notes on background material. Bibliographical references to some of this material are posted by the seminar directors; the remainder is found by the students themselves through the use of the library card catalog, periodical guides, lists of research books, etc. A course in "Exposition and Persuasion" required of all sophomores at Marygrove has grounded the students in the techniques of library research as well as the organization of material, the elements of clear, forceful style, and the techniques of public discussion—all of which are put into practice in the seminar. At the beginning of each scholastic year the juniors are taken in small groups through the college library and have the tools most useful for their particular seminar pointed out and explained to them.

DEPARTMENTAL MEETINGS

In preparation for the departmental meeting each week the seminar directors draw up and post on the bulletin board a topical outline which includes the important principles, facts, and preliminary problems to be considered by the group as a foundation for the

[1] STUBBLEFIELD, F. M., "Education of Chemists," *Chem. & Eng. News*, **23**, 1951 (1945).

seminar itself. During departmental meetings a student presides and the discussion is informal. While the emphasis here is on facts and principles rather than on problems, the students strive to make their contributions interesting and forceful. There is no mere reading of notes, although notes may be used. Authorities are evaluated as well as quoted. The seminar director listens carefully during these departmental meetings, frequently joins in the discussion, and offers suggestions as to improvement of both content and expression of student contributions.

SEMINARS

During the weekly interdepartmental meeting the chairman and the students presenting papers sit at the front of the room facing the rest of the group. The seminar opens with a brief introduction by the student chairman summarizing the preceding seminar and correlating both it and the program for the day with the general problem for the semester. The chairmen then formally introduces in turn the students (usually three) who present the papers for the day. These students speak directly to the audience and are not allowed to use notes except in the case of a long quotation. The student listeners take notes. The introductions and papers usually take about 25 minutes, and when they are finished, the remainder of the hour is devoted to a discussion of the papers. This discussion may include the expression and support of an opinion at variance with that upheld by one of the speakers, the questioning of the speakers, the addition of relevant information, citation of examples to prove or disprove the propositions upheld by the speakers, or comment. The chairman guides the discussion without entering into it and attempts to bring as many of the listeners into the discussion as possible. The faculty members grade the papers presented, correct any vital error made during the discussion, and keep a record of student contributions.

Within a week each student speaker submits to her seminar director the final copy of her paper typed according to manuscript regulations, properly footnoted, and complete with outline and bibliography. Thus careful training in research and discussion is given the students enabling them to express their ideas with clarity. But what of the subject matter of the course? How does it develop the students?

FOUR-SEMESTER CYCLE

The four-semester cycle of courses for the chemistry and biology departments consists of a study of public health, the effect of science on the progress of civilization, the impact of modern science on our social institutions, and, finally, the relationships existing between science, philosophy, and religion.

For the study of public health, the chemistry department works with half of the sociology department, the other half pairing off with the department of biology. The two groups are independent, and while their plans for the semester differ in many respects, they both begin with a study of federal, state, and local agencies working in the field of public health and with the work of the great foundations like the Red Cross operating on a national and even on an international scale. While the problems considered differ not only among the two department groups according to their special interests, but also from year to year depending upon world conditions and the timeliness of particular aspects of public health, special consideration is always given to the duties and rights of the state and the individual. Problems arising from the interplay of these rights and duties are the subject matter of student papers and are settled on a broad unselfish basis that carries over into ordinary living. Once the right of the state to quarantine and to require premarital examinations is recognized, the rational basis for future cooperation between these young citizens and the government is established. The priority of the rights of the individual in such problems as euthanasia and sterilization is proved.

Water purification and sewage disposal which involve so much simple chemistry and bacteriology are given special consideration because of the present threat to America caused by her dying rivers and polluted streams. The need for regional planning and cooperation is stressed. Mental health, drug addiction, rehabilitation of the disabled veterans, and other timely topics are given their share of attention.

The effect upon the chemistry and biology students is a broadening one, causing a respect for their own chosen fields (Who dreamed that chemicals could affect mental health?) and a deeper appreciation of the interplay of the sciences with other fields of human knowledge.

The effect of science on the progress of civilization is studied by the departments of biology, chemistry, history, and mathematics working together as a single large unit. The beginnings of science in Babylon, Egypt, and Greece; the union of science and philosophy in the Middle Ages and their divorce at the time of Galileo and Kepler; the great industrial revolution—these are but a few of the high lights of scientific development seen against the background of world history. The repercussions of each major discovery, the students find, had a profound effect, either for good or evil; upon the progress of civilization. Thence arises the problem: under what conditions is a scientist responsible for the good or evil effects of his discovery? Here again, can the effects of such study on a science student be anything but broadening and unifying? Against a background of such depth even the most amazing developments of modern science are seen in the proper perspective.

For the study of the impact of modern science on social institutions (the work of the present semester) the biology and chemistry departments each pair off with half of the department of economics, again forming two independent groups. Such major questions as the following are being considered:

1. Has the advance of science tended to strengthen or weaken democracy?
2. Has the influence of science been a factor for good or evil in education?
3. Has science made the home a better place in which to live?

Specific problems, subjects of individual papers, include the following:

1. Has the radio strengthened democracy in this country by arousing, public interest in government?
2. Is the secrecy in which many recent scientific discoveries are shrouded a desirable thing?
3. Is the government direction, coordination, and support of scientific research tending to weaken freedom of inquiry?
4. Is the discovery of the atomic bomb (a product of cooperative research under federal control) a contribution to the true progress of mankind?
5. Does the rapid advance of science tend to make monopolies inevitable?
6. Have the effects of science on community life necessitated a shift from the study of the classics to the physical sciences?
7. Can a woman successfully combine a scientific career with marriage?
8. May the "movie" be considered a major factor in the weakening of parental influence in the home?
9. Has science any responsibility in stemming the steady decline of the population in our country?

Because of the general interest in the problems under discussion, the students find this seminar the most fascinating and integrating one in which they have as yet participated. This particular group of students, however, has had no experience with the last course of the cycle—the relationships existing between science, philosophy, and religion.

For this last course of the two-year cycle, the biology, chemistry, and mathematics departments combine again in one large group. Since all Marygrove students are required to take 16 hours of philosophy in their junior and senior years, and since all Catholic students take one hour of religion each semester during the whole four years, the science and mathematics majors involved in this seminar have at least the basic knowledge of the big three about which they talk. Part of the course is devoted to what is called the philosophy of science and another major section to establishing the truth of the statement that there is no conflict between religion and science. Many of the myths that have grown up about the supposed antagonism between the Catholic Church and science are investigated and exploded. And finally the seminar considers science and the supernatural about which so much erroneous material has of late been written. This seminar strengthens young science majors in their faith in religion and in science, and gives them true important ideas to express with clarity.

Thus we can conclude that this four-semester, eight-credit-hour cycle of courses makes a valuable contribution to our science majors, not only by training them in research and discussion, but also by being an integrating factor in their total education.

PREAMBLE TO THE CONSTITUTION OF THE UNITED NATIONS EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANIZATION

The Governments of the States Parties to This Constitution on behalf of Their Peoples Declare:

that since wars begin in the minds of men it is in the minds of men that the defenses of peace must be constructed;

that ignorance of each other's ways and lives has been a common cause throughout the history of mankind of that suspicion and mistrust between the peoples of the world through which their differences have all too often broken into war;

that the great and terrible war which has now ended was a war made possible by the denial of the democratic principles of the dignity, equality, and mutual respect of men and by the propagation in their place through ignorance and prejudice of the doctrine of the inequality of men and races;

that the wide diffusion of culture and the education of humanity for justice and liberty and peace are indispensable to the dignity of man and constitute a sacred duty which all the nations must fulfill in a spirit of mutual assistance and concern;

that a peace based exclusively upon the political and economic arrangements of Governments would not be a peace which could secure the unanimous, lasting, and sincere support of the peoples of the world and that the peace must therefore be founded, if it is not to fail, upon the intellectual and moral solidarity of mankind.

Operating an Abstracting and Information Service within an Industrial Organization

W. C. E. BARNES

Arc Manufacturing Company, Ltd., London, England

IN AN industrial concern with a varied field of interests the amount of time at the disposal of the various departments is not sufficient for keeping abreast with the current literature received by the firm and circulated among its staff. It is therefore expedient to have some means of selection so that articles of interest, which might otherwise be overlooked, may readily be brought to the notice of those persons whom they most concern. The method adopted in the Arc Manufacturing Company is the organization of an internal abstracting and information service functioning for that and associate firms.

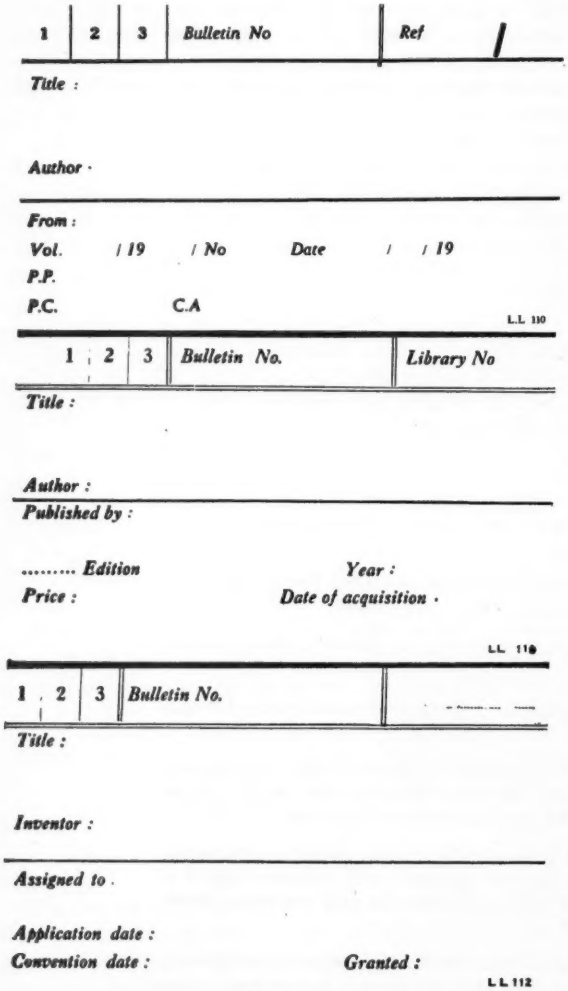


FIGURE 1

The Arc Manufacturing Company receives regularly a large number of journals, trade publications, patents, etc., covering a variety of subjects which are obviously not of equal interest to all members of the staff; therefore, as an aid to selection of literature, a bulletin is issued by the librarian through the information service which contains only selected literature. All incoming material is thoroughly searched for articles of interest which are to be abstracted or just noted according to the value of the information they contain. The heads of the departments classify the articles on looking through the journals and indicate, for the guidance of the librarian, whether the abstract given is sufficient or whether another should be made. The following signs made against the titles are used as an indication of what is required:

√ = Reference card only, to be included in bulletin.
× = Reference card only, not for inclusion in bulletin.
○ = Reference card and abstract to be copied for bulletin.
⊗ = Reference card and abstract to be made for bulletin.
‖ = Literature to be ordered.
P = Photostat copy to be made.

In this way the actual abstracting of the literature is much simplified. As a general rule, if an article is already provided with a good abstract, this is used, acknowledgment being made to the source; the abstracting of other articles is shared between members of the research staff, the reference cards being passed on to the appropriate persons after the reference data have been filled in. If a photocopy is to be made, this is also indicated on the card. When the reference cards have been made out, the signs in the journals are covered over with colored seals; a yellow seal indicates that an abstract has been made for the bulletin, and a blue seal stands for a reference card in the index only. The seals also eliminate the untidy appearance of scribbled remarks in journals. Not until journals have been fully dealt with and signed off by the librarian are they released for circulation among the various departments; however, this delays circulation for not more than four days.

References and abstracts thus collected from the original literature are indexed on the usual 3 × 5 index cards which, for convenience, have been printed in three standard forms. The three different types are used for: (1) references to articles taken from periodicals, (2) references to books and self-contained publications, and (3) recording patents (see Figure 1). Each card indicates the necessary features to be noted; abstracts are written on the backs of cards. There is also a color classification which brings groups of allied subjects together—the color code persisting throughout the three types of reference. This makes for special ease when sorting out new references for filing and in picking out cards from an author index. We have also found that the use of a printed card drawn up in a standard form is of great assistance when compiling a bulletin from the collected abstracts.

Bulletins contain usually 150 abstracts grouped under subject headings, numbered consecutively, and circulated together with a form for ordering. Reference on order forms need then be made only to the bulletin number.

As many of the references dealt with are seen only in abstract form in the first instance, it is, of course, necessary to borrow or order photostat copies of a large proportion of the literature required from one or another of the large technical libraries. To keep a check on incoming and outgoing literature of this kind and to facilitate its distribution within our organization, we have designed a record book of which a facsimile page may be seen in Figure 2. Passing from left to right across the page, the first column shows the number of the reference. This is followed by a group of narrow columns at the top of which may be written the name of the individual or department requiring the literature, a diagonal line being drawn across the column to indicate an order. In the third place is written the reference, giving author and source, and the remainder of the page is divided between the various libraries normally drawn upon, with a spare column for any other library it may be necessary to resort to for specialized information unobtainable elsewhere. When literature is applied for from any library, an indication together with the date is written in the appropriate column. When a reply is received from the library its nature is indicated by a colored seal—green, pink, yellow, or blue—to show whether the literature itself is received, already out on loan, unobtainable, etc., explanatory footnotes for the color code being provided. If the literature applied for is definitely not available, then the same procedure is carried out again for another library. In this way it is possible to see at a glance what attempts have been made to obtain, and what chances remain of obtaining, the literature required.

Borrowed periodicals are not circulated, but photostated and returned immediately to the appropriate library. When a borrowed book is returned, the date of return is entered against the "book received" entry so that its record is completed. Finally, when the literature is passed on to the enquirer a second line is drawn across the original mark indicating the request, and when the copy is returned, the date is entered below the cross.

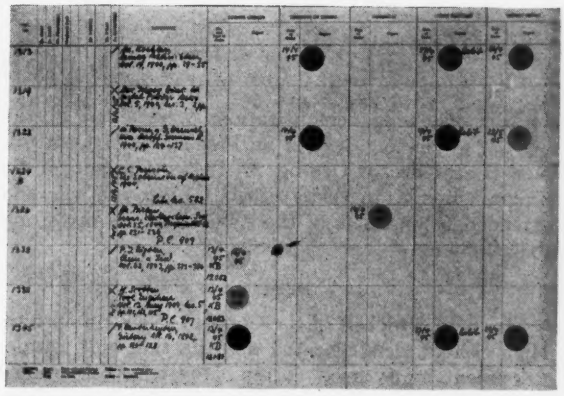


FIGURE 2

This method of recording we have found to be very simple to operate and an easy means of keeping track of both outstanding requests for literature and books borrowed.

On account of this policy of photocopying borrowed literature before distribution, the checking, entering, allocation, and filing of such copies require a considerable amount of attention. In order to keep a check on library loans which have been passed on for photocopying and to assist in the proper entering, allocation, and filing of prints, a duplicate order book system has been adopted. These books contain printed forms, numbered in duplicate, on which is filled in all the revelant information which will be required after the photocopy has been made, *i. e.*, title, author, and source for entry purposes; name of individual(s) requiring the copy; bulletin number if already available; and instructions for filing. Such a form is handed out with each piece of literature to be copied (the duplicate remaining with the librarian as a record of literature handed out), and must be returned with the completed print, negative, and the original literature for checking purposes. Entries of prints are recorded in a bound book in which each is given a serial number. This number, and the number of pages in the copy, are written on the top page of the print, together with a filing reference. The photocopy number is always referred to when a further print is made, as all the negatives are filed in numerical order in envelopes with printed labels on which is copied all the relevant information from the order form. The photocopy number is also entered on the appropriate reference card in the card index.

This method has now been in operation for more than 18 months and has proved very workable.

Report of the NEW ENGLAND ASSOCIATION of CHEMISTRY TEACHERS

Demonstrations

THE following demonstrations were given at the 232nd meeting, held at St. Paul's School, Concord, New Hampshire, on October 27, 1945. This part of the program was arranged by Elbert C. Weaver, who had extended to members of the Association an invitation to participate.

DYEING

Mr. Seth Twichell of the Concord, New Hampshire, High School, demonstrated diazotization and the development of dyes on cotton. Swatches of cleaned cotton cloth were impregnated with primuline. These were immersed in a diazotizing bath containing freshly-made nitrous acid. After diazotizing, the dyes were developed by a variety of agents, amines and phenols, including beta-naphthol, for example—some of them original with the demonstrator. A notebook of swatches was displayed showing brilliant, clear colors that had brought favorable commendation from textile colorists.

NATURAL INDICATORS

Dr. David L. Davidson of Gustavus Esselen Company, Boston, showed the changes of various natural indicators at several places on the *p*H scale. An infusion of carrot stems was prepared. A portion was mixed with alkali suds (soapy water), and another portion with acid suds (acetic acid and an organic detergent). The intense yellow that the tomato gardener notices when washing his hands was observed in the first case, but no color in the second. On the addition of sodium hydrogen carbonate to the acid suds, and later 20 per cent sodium hydroxide solution, the intense yellow was developed there also.

A similar series of experiments was performed with the juice of red cabbage, but a different set of color changes developed.

SCRAP MAGNESIUM

Mr. Harry Wiley of Laconia, New Hampshire, High School remarked on the laboratory possibilities of scrap magnesium. The scrap metal is available for $0.10 per pound from Scott and Williams, Laconia, New Hampshire. With dilute sulfuric acid it replaces hydrogen satisfactorily, is cleaner than the commercial mossy zinc, and is much more effective. A disc of the metal was displayed. It weighed 24 grams, or one mol, and represented 6.06×10^{23} atoms. A 15-degree segment would weigh one gram and contain 25 billion trillion atoms. The density of the specimen was less than 1.8, and it was carried as a pocket piece. Such an exhibit, claimed Mr. Wiley, is more effective than the 22.4-liter empty box as a demonstration of the mol.

GRAM MOLECULAR VOLUME

Turning to the 22.4-liter box, Mr. Elbert C. Weaver of Phillips Academy, Andover, Massachusetts, demonstrated a way to show tangibly what the box contained. From within the box he pulled out a show card inscribed, "This box contains 22.4 liters, the gram molecular volume of any gas at STP;" and on the reverse, "For example, 22.4 liters at STP holds 2 g. of hydrogen, 32 g. of oxygen, 17 g. of ammonia, 22 g. of carbon dioxide."

COLORED SMOKES

From among the colored signal smokes, the orange smoke was demonstrated.[1]

OXYGEN FROM HYDROGEN PEROXIDE

The investigation of the possibilities of using 30% hydrogen peroxide as a demonstration material was discussed,[2] and the violent catalytic decomposition of 30% hydrogen peroxide with a pinch of manganese dioxide was shown. At first the test for oxygen was brilliant, but later a flaming splinter was extinguished by steam from the boiling water.

COMMITTEE ASSIGNMENTS

President Millard W. Bosworth has announced the following committee appointments for the year 1945–46:

Summer Conference Committee: Prof. Ina M. Granara (chairman), Simmons College, Boston 15, Massachusetts; Dr. Otis E. Alley, Dr. Lawrence H. Amundsen, Mr. John K. Bodel, Miss Helen W. Crawley, Miss Gertrude T. Eastman, Rev. Bernard Fiekers, Dr. Ernst Hauser, Mr. George Hearn, Dr. Henry S. Johnson, Dr. Eldin V. Lynn, Prof. W. B. Meldrum, Miss Edna Robbins, Mr. Howard A. Smith, Dr. Harriet Southgate, Mr. Paul F. Stockwell, Mr. John R. Suydam, Prof. P. Conant Voter, Mr. Elbert C. Weaver, Mr. M. W. Bosworth (*ex-officio*), Mr. T. C. Sargent (*ex-officio*).

Chemical Education Committee: Mr. A. F. Williston (chairman), Miss Dorothy Abel, Mr. Eugene Biddle, Mr. Harold Coburn, Mrs. Marjorie Fentery, Mr. Ralph Keirstead, Miss Evelyn Murdock, Mr. Andrew J. O'Connell, Mr. William N. Stakely.

Honorary Membership: Dr. Eldin V. Lynn, Mr. Theodore C. Sargent, Mr. Raymond E. Neal.

Necrology Committee: Mr. S. Walter Hoyt for 3 years.

[1] Kieffer, W. F., and J. M. Resko, THIS JOURNAL, 22, 385 (1945).

[2] Stone, C. H., *ibid.*, 21, 300 (1944).

LETTERS

To the Editor:

I wish to express my enthusiastic approval of your editorial on compulsory military training in the December JOURNAL OF CHEMICAL EDUCATION. The army has a reputation for wasting the soldier's time. We say in colloquial language that a person "soldiers," meaning that he makes a mere show of working. The age toward the end of high school or the beginning of college is the time when professional and technological abilities begin to develop. It is particularly important at that time to stimulate and foster this development, to teach young men to extend their minds to the utmost, to venture into greater responsibilities and not to avoid them.

WALTER B. KEIGHTON

SWARTHMORE COLLEGE
SWARTHMORE, PENNSYLVANIA

RECENT BOOKS

VIRUS DISEASES IN MAN, ANIMAL AND PLANT. *Gustav Seiffert*, translated by *Marion Lee Taylor*. Philosophical Library, New York, 1944. ix + 332 pp. 14.5 × 23 cm. $5.00.

The stated purpose of the author is to present a survey of recent literature concerning the most important virus diseases of plants, animals, and man, since virus problems can best be understood by a comprehensive knowledge of the entire field.

The first part of the book is a discussion of the general nature of viruses, including a description of some of their physical and chemical properties, methods of cultivation, pathology, immunology, and epidemiology.

The second part deals with diseases caused by viruses. The descriptions of sixteen groups of animal diseases include the following and their relatives: variola, herpes, hoof and mouth disease, trachoma, molluscum contagiosum, measles, ectromelie, influenza, yellow fever, cattle plague, infectious anemia, mumps, poliomyelitis, rabies, encephalitis, and whooping cough. Some of the diseases discussed seem to have doubtful relationships to viruses. An example of the author's unwillingness to draw definite conclusions with respect to the etiology of a common disease is the following statement: "All proofs that scarlet fever is a virus disease seem not yet to be fully contradicted." A section dealing with vira and new growths presents evidence which supports the view that filtrable substances can produce new formations. The author takes a conservative view with respect to viruses generally, as the cause of neoplasia, and warns against premature conclusions in the cancer field.

The section on virus diseases in plants (10 pages) seems too brief when one considers the important contributions in this field which have been made to our knowledge of the chemistry of viruses. Bacteriophage also is discussed too briefly.

Although the copyright is dated 1944, references to the original literature are not later than 1937. The translator might have made the book easier to read by departing further from a literal style with its frequently awkward sentence structure and peculiar word forms. The publisher could have improved the format for American readers. Numerous odd errors, such as microspirometer (p. 9), instead of microrespirometer, soluble particle (p. 25) in place of resolvable particle, epizooties (p. 99) for epizoötics, vitreous tumor (p. 131) instead of vitreous humor, etc., do not improve the reading quality.

Seiffert has not very well succeeded in presenting a clear picture of the biology and chemistry of viruses. A successful book cannot be built by assembling choppy sentence references to the problems to which investigators have given their attention. In a specialized book, the reader can rightfully expect some synthesis of knowledge as a result of the author's critical evaluations of the technical literature.

Throughout this book, the author should be commended for pointing out numerous problems which require further investigation. An example may be cited on page 51: "So far no chemical substance is known that affects vira in the body destructively or with influence on the disease. Chemical therapy of virus diseases is therefore impossible at this time." In his discussion of immunology (p. 74), the author states that in viruses "the antigenic structure is as good as not worked on at all." Such statements should offer a challenge to new investigators, for whom a section on methods of studying viruses is included at the end of the volume. In conclusion, the book contains an important array of facts, presented in a less inspiring manner than one might reasonably well have expected.

PAUL R. BURKHOLDER

YALE UNIVERSITY
NEW HAVEN, CONNECTICUT

ELECTRONICS: TODAY AND TOMORROW. *John Mills*, Sometime Member of the Technical Staff, Bell Telephone Laboratories. D. Van Nostrand, Inc., New York, 1944. 178 pp. 13 × 19.5 cm.

"Electronics" is a delightful book for the intelligent individual who knows little physics and no electronics. It is the reader's own fault if, when he finishes, he does not know the difference between a triode and a magnetron.

Mr. Mills begins with a rapid-fire description of the growth of knowledge of the electron itself, first as it relates to atomic structure, then as it produces large-scale electrical effects, and finally as it behaves in discharge tubes. He uses simple colloquial English but manages to include such terms as deionization, electrode, and "electron-moving-force" in his brief development of electronic fundamentals.

From these beginnings, "Electronics" turns to a discussion of the "radio-tube," diodes, triodes, tetrodes, and pentodes, taking time out now and then to discuss evaporation of electrons from a hot wire, rectifiers, oscillators, photoelectric tubes, and gas-filled power rectifiers. The treatment is sufficiently complete to include the phenomenon of space charge, but is in all cases limited to a qualitative discussion.

The second half of the book deals with other electronic devices Electron guns and television, the electron microscope, and ultra-high frequency generators such as the magnetron and klystron obtain their share of space. The treatment of these devices is nontechnical, but enough information is presented to give the reader a clear concept of the uses, advantages, and disadvantages of each. The final chapter describes the cyclotron and its operation. The only observed error of the book occurs here when a neutron is indicated as a possible "accelerated particle" in a cyclotron.

One striking lack in the book is diagrams. A few well-chosen and properly placed line drawings would aid enormously in the presentation of material which is essentially strange to and unpictured by the mind of the average reader.

"Electronics" was written during the war years and does not include any information on the very latest phases of electronic research. The whole subject of radar is lacking, frequency

modulation is given only passing mention, and the newest developments in u-h-f are completely missing. However, this book will provide a valuable background of information for the nontechnical individual and allow him to listen intelligently to the discussions of returned veterans who have been trained in the use of radio in modern warfare.

E. P. LITTLE

EXETER ACADEMY
EXETER, NEW HAMPSHIRE

THE CHARACTERIZATION OF ORGANIC COMPOUNDS. *Samuel M. McElvain*, Professor of Chemistry, University of Wisconsin. The Macmillan Company, New York, 1945. ix + 282 pp. 14 × 21 cm. $3.40.

The general acceptance and recognition of the value of instruction in the identification and characterization of organic compounds are certainly some of the most outstanding pedagogical developments in the field of chemistry of this generation. The paucity of texts in this subject is a tribute to the excellency of those which have appeared. It is a pleasure to welcome an additional well-written book to this small group. McElvain writes with a sureness of touch which reflects his 22 years of teaching the "Characterization of Organic Compounds" at the University of Wisconsin.

The book is written in a clear straightforward style and includes without apology excellent reviews of such basic laboratory techniques as recrystallization, determination of melting points and boiling points, etc. The material is taken up in the logical order of the usual steps in the actual laboratory characterization of organic compounds: (1) the determination of the physical properties and the establishment of the purity of the compound; (2) determination of the class of compounds; (3) location of the compound within a class; (4) preparation of derivatives. An outstanding characteristic of the book is the constant attempt to explain the reasons for things. Particularly excellent is the discussion of solubilities in terms of dipoles, hydrogen bonding, etc.

The scheme of analysis is in general standard. It might be mentioned, however, that the sulfuric-acid-soluble alcohols, aldehydes, ketones, and esters are not subdivided into those soluble and those not soluble in phosphoric acid. While 60 laboratory experiments are provided, the text maintains one of the primary values of qualitative organic analysis in never becoming a routine cook book. Excellent suggestive footnotes add no little to the value of the whole.

Your reviewer ventures the prediction that "McElvain" will be well liked by students, that it will be widely used, and that it will achieve one of the major purposes of its author: "helping the student to organize, orient, and consolidate the too often unwieldly mass of information acquired in the study of elementary organic chemistry."

OSBORNE R. QUAYLE

EMORY UNIVERSITY
EMORY UNIVERSITY, GEORGIA

THE TECHNOLOGY OF PLASTICS AND RESINS. *J. Phillip Mason*, Professor of Chemistry, Boston University, and *Joseph F. Manning*, Lecturer on Chemistry, Boston University, and Research Chemist, B. B. Chemical Company. D. Van Nostrand Company, Inc., New York, 1945. viii + 493 pp. 177 figs. 16 × 23.5 cm. $6.50.

This book covers a wealth of material and should prove to be a useful addition to the literature on the subject, particularly for educational purposes. It is divided into three sections: "Macromolecules and Their Properties," "Plastic Types," and "Fabrication." Section Two is particularly to be commended as a broad review of the commercial plastics with their physical properties and chemistry. The emphasis throughout has been given to practical considerations so that a student mastering the contents of this book should have a very good introduction to that side of the subject.

In view of the fact that a student rarely improves his theoretical foundation after leaving college, it is to be regretted that the book has not given more space to this branch of the subject. The reviewer feels that Section One on "Macromolecules and Their Properties" is very inadequately treated. The subdivision of plastics into three major groups—natural, synthetic, and artificial—seems quite superficial. The two and one-half pages devoted to the amorphous state are inadequate, and the section on colloidal characteristics is uninspired. Chapter Two on "The Plastic State" is sterile. It could well have been an essay laying a foundation for an understanding of the information to be gleaned from later sections of the book.

A number of careless errors have crept in to disturb one's confidence in the accuracy of detail. For example, it is stated that "The values of the dielectric constant represent the effectiveness of a material as an insulating medium. . . . Two plastics with high dielectric constants are polystyrene and polyethylene." The optics of Figure 5.19 is wrong. On page 169 it is erroneously stated that when hexamethylenetetramine is added to a Novolak resin, it decomposes to produce formaldehyde and ammonia, the former then reacting to produce methylol groups on the resin. Again, the statement is made that most aniline formaldehyde resins are made from equimolecular amounts of aniline and formaldehyde.

To the reviewer it seems that the review questions at the ends of the chapters would be comparatively useless even to the more stupid students and that it would be much better to substitute lists of selected reading references.

The book is well printed on good paper and is profusely and well illustrated.

S. S. KISTLER

THE NORTON COMPANY
WORCESTER, MASSACHUSETTS

LUMINESCENCE OF LIQUIDS AND SOLIDS. *P. Pringsheim* and *M. Vogel*. Interscience Publishers, Inc., New York, 1943. x + 201 pp. 15.5 × 23.5 cm. 72 figs. 22 tables. $4.00.

The widespread occurrence of luminescence, its many possible applications to chemical analysis, and the technical importance of luminescent materials in lighting, television, and other fields combine to make this subject of interest to the chemist. As an introduction to the behavior of condensed systems which radiate energy by virtue of optical or electrical excitation, Pringsheim and Vogel's book is to be recommended.

Particularly helpful to the reader without experience in this field is a short chapter on experimental technique, wherein the equipment and methods used to excite luminescence and to study the properties of the emitted radiations are discussed. Two additional chapters, one providing a theoretical background and the other dealing with the more common luminescent chemicals themselves, complete the general discussion. The chapter on theory is lamentably short, and devotes a disproportionate amount of space to such topics as an elementary review of the nature of light, the methods of expressing and calculating phosphor efficiencies, and the production of white light by color addition. Such matters as the structure and energy level scheme of crystalline solids, the absorption of energy and its transfer to the luminescent centers, and the role of activators in the impurity-activated phosphors deserve more than the brief and very general discussion allotted to them. The section on luminescent materials is likewise too abbreviated, fluorescent glasses, for example, being discussed in two paragraphs. Enough material is included, however, to give the reader a fairly good idea of what is available in the way of luminescent substances and how they are prepared.

The second half of the book deals with the practical applications of luminescence, including fluorescence analysis, luminescent paints, screens, and light sources. The chapter on analysis is an excellent survey of the applications of this method to inorganic, organic, and biochemistry, as well as to many industrial problems and products.

The illustrations are numerous and well done, and several hundred references to the original literature are given.

JAMES H. SCHULMAN

SYLVANIA ELECTRIC PRODUCTS, INC.
SALEM, MASSACHUSETTS